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AGRICULTURAL ENGINEERING

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An Ag Engineer's Concepts of Farm Building Management *Deane G. Carter*

Equipment and Procedures for Farm Tractor Tire Studies *I. F. Reed and M. O. Berry*

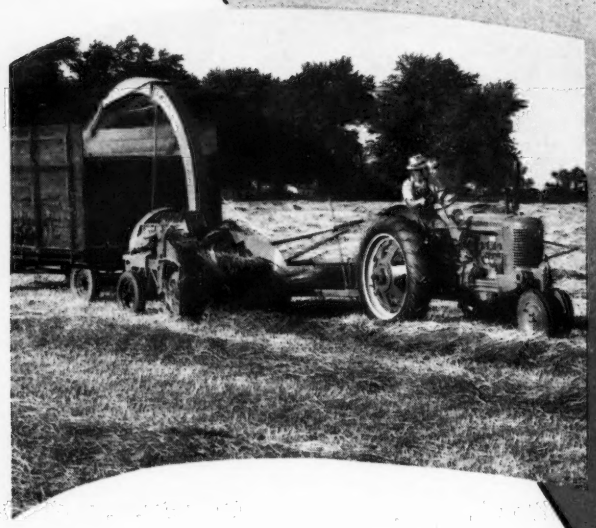
A Steel Structure Adapted to Drying Corn with Forced Air *David B. Poor*

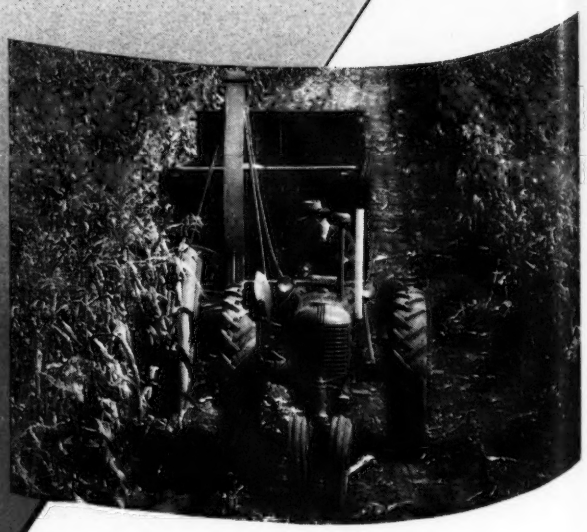
An Agricultural Engineer's Tile Drainage Experience *John R. Haswell*

Development of a Water-Spreading Irrigation System *Clarence F. Vogel*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

More Nutrients
Per Man Hour





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EDITORIAL

Another Curriculum?

THE academic responsibilities of the agricultural engineering departments in our colleges and universities are both innumerous and diverse, judging from the activities currently conducted at various institutions. Listing these in a chronological sequence, we find six types of educational programs:

1 *Vocational.* The excellent cooperation with vocational high school educators during recent years is resulting in the introduction of agricultural engineering principles at this "grass roots" level. The work at Pennsylvania State College and the cooperative program now being initiated by the institutions in the Southeast are outstanding examples.

2 *In-Service Training.* One or two-year short courses of the type being conducted by Michigan State College cooperatively with the farm machinery dealers of that state and by Iowa State College, for young men desiring to enter rural construction or retail material dealer employment, will do much toward training enlightened mechanics and service personnel for agriculture.

3 *Service Courses.* Required and elective courses for students majoring in the various agricultural curriculums constitute the major teaching load of every department. This will doubtless increase as more such curriculums are "modernized" to include agricultural engineering as a major phase of present-day agriculture — "of equal importance with animal industry, plant science, soils, and management."

4 *Professional Curriculums.* With the new emphasis on accredited professional curriculums and the increasing enrollments in such curriculums the technical agricultural engineering subject matter courses assume added importance. Their content and presentation interest the entire profession.

5 *Graduate Studies.* With the increasing scope of agricultural engineering and the demand for better-trained men no institution offering a professional curriculum can long delay offering advanced work. The time has passed when basic training will suffice for academic and research progress.

6 *Industry Conferences.* Too few institutions are capitalizing on the advantages of sponsoring annual conferences of a few days duration with the various groups of engineers serving agriculture in their states. Soil conservation, building, machinery, and electrification conferences have been held successfully. The machinery conferences conducted at the University of California for the past 20 years are an outstanding example.

With so many teaching responsibilities crowding understaffed departments, it is unfortunate that a misunderstanding has arisen relative to the objection by some agricultural engineers to the suggestion that another be added — a curriculum leading to a "BS degree in agriculture with a major in mechanized agriculture." The stated objective, training prospective farm operators in all the varied phases of modern mechanized farming, can best be accomplished by reorganizing all agricultural curriculums to this concept. To do so will place more agricultural engineering service courses in the various agricultural curriculums.

Or, it may be desirable to organize a farm operations curriculum under farm management or one of the production departments, with twenty or more credit hours from the agricultural engineering service courses included. To present such a curriculum as an agricultural engineering major, however, is confusing and detracts from the professional curriculum.

If, however, the agricultural engineering curriculum of any institution is not to be developed into a professional curriculum, meeting the standards now developed for such curriculums, then the name should be changed to the "mechanized agriculture" major. By this change the institution can cooperate in the intent of the resolution recently passed by the Association of Land-Grant Colleges and Universities.

J. DEWEY LONG

Farm Power Management

A LOT of former two-horse farmers and quite a number who used to have larger numbers of hay burners around the place, now have 10 to 100 hp or more at their command in the shape of tractors, plus some additional power in motor trucks, electric motors, and stationary engines.

In comparison, some recent figures indicate that power per urban industrial worker has increased from practically zero in 1849 to better than 7 hp at present.

Significant numbers of farmers control more power per man than their contemporary workers in the urban industries.

Undoubtedly the highly organized and engineered urban industries figure their power requirements more closely than do farmers. They keep a minimum of "horses" on pasture as standby power.

Optimum available horsepower for any specific farm and plan of farm operation can also be figured closely. It can be done in terms of estimated costs and advantages of maintaining various levels of capacity to handle unavoidable load peaks within time limits imposed by biological and weather probabilities.

Several factors suggest that this close figuring would support the practice of many prosperous farmers in maintaining liberal power capacity per worker, even with load factors per power unit much lower than those common in manufacturing and transportation.

1 Farming may properly be considered one of the "heavy industries." It is heavy in the mass of its aggregate production. It is heavy in ton-miles of work accomplished on individual farms. It uses heavy equipment to overcome large gravity, friction, and other loads. It moves, manipulates, and controls heavy masses of soil, water, air, miscellaneous supplies, and unsalable crop components per unit of salable concentrate. In forces applied, masses handled as units, and force-time-space relationships it compares with many operations in the steel industry.

2 In farming, weather writes the work orders. It may call for little or no power one day, and 2,000 or more horsepower-hours on the same farm the next day. Power capacity to handle jobs during short critical periods when weather, soil, and crop conditions are favorable may mean the difference between profit and loss on a year of operations. Reserve power capacity on farms over and above normal field work peak requirements, is a form of insurance. Its cost and its possible value in reducing risk should be balanced on an actuarial basis.

3 The movable general-purpose power unit is a practical means of minimizing power capacity requirements only within certain rather evident limits. Tractors and trucks in the same power range are only partially interchangeable. Even a small general-purpose tractor cannot be used economically to any extent on ¼-hp belt jobs. Neither can the combined power of several small motors be applied effectively to many of the larger farm power jobs. The advantages of automatic operation generally justify individual motors on water systems, refrigerators, ventilators, and similar installations.

It is true that farms can be overpowered. And faulty farm operation or misfortune can readily cancel out the economy of power use. With a hundred or more horsepower under his control a farmer can carry out either sound or unsound practices, or some of each, on a fairly grand scale.

Farmers are going to find out sooner or later, by trial and error if necessary, just about how much power they can use, and how they can use it to best advantage. To help them find out sooner, and with less error, something better than rule-of-thumb guides to good practice are needed. Engineering equipment, methods, and cost factors are involved to a large extent. This suggests an opportunity for agricultural engineers to serve the mutual interest of farmers and the farm equipment industry in farm power management.

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AGRICULTURAL ENGINEERING

VOL. 30 FEBRUARY, 1949 No. 2

Some Concepts of Farm Building Management

By Deane G. Carter

FELLOW A.S.A.E.

A PRIMARY definition of *science* is "any branch or department of specialized knowledge considered as a distinct field of investigation or object of study." According to this definition, "*farm structures*" is not just a subdivision of structural design, architecture, or farm management, but a separate science combining farm building design, its modification to meet various requirements, and its application to the conditions and circumstances of agriculture.

In farm structures development, the engineer has been concerned chiefly with structural elements, methods of construction, space design, utilization of materials, building equipment, environment, and function. Although design is important, in a science of farm structures it is also necessary to consider the modification and application of design. The latter two, which are management aspects, are intimately associated with the valuation of structures and their relation to farming systems, individual farms, and specific enterprises.

Most farmers are fully aware of the significance of building management in the farming program. The urgency of the problem is further emphasized at this time by rapidly changing conditions and new developments. Changes have occurred not only in agriculture, but also in the costs, materials, and methods of obtaining buildings. The qualified manager knows something of the penalty he pays for lack of buildings in terms of livestock losses, spoilage, reduced market prices, low-grade products, and inefficient use of labor.

At the same time, the manager is faced with such problems as adding $100 or more an acre to his capital investment if he builds a new house and barn, having to abandon some farmsteads altogether in the consolidation of small farms, having his farming system hampered by buildings already on the farm, or having to use cheap, temporary, or inadequate structures. Farmers need to know building costs and values, in order to give more careful attention to the division of expense between tenant and landlord, and in order to plan an improvement program that will ultimately offset accumulated deficiencies and establish needed new facilities.

Both the engineer and the farm manager are concerned with these problems as well as with farming practices in mechanization, electrification, and soil conservation which affect building needs. The significance of farm building management can be suggested briefly by the following statements:

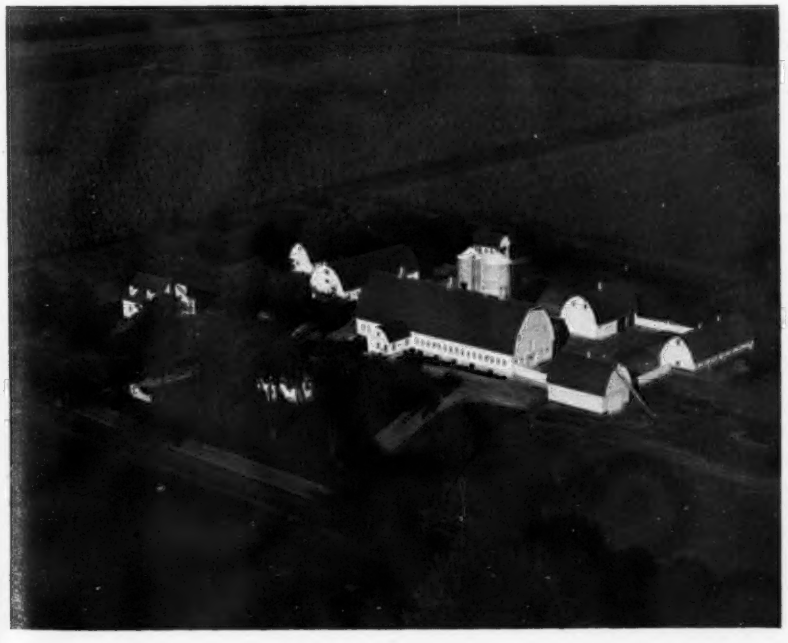
Conditions since 1919 have been generally unfavorable for extensive farm building improvement. As a result, existing buildings are out of line with present requirements, and managers are faced with the need for extensive and expensive building rehabilitation.

Building costs have increased rapidly. Many building costs doubled from 1932 to 1940, and doubled again between 1940 and 1948. Only at rare intervals is there a balance between farm prices and building costs. In late 1948, building costs were at record high levels, while farm prices were declining. Even at peak incomes, money is not available to many

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Farm Structures Division. Some of the information in this paper is taken from the author's thesis for the professional degree of Agricultural Engineer, entitled "Farm Building Evaluation, Appraisal, and Long-Range Planning."

DEANE G. CARTER is professor of farm structures, agricultural engineering department, University of Illinois, Urbana.

ACKNOWLEDGMENT: Credit is due J. B. Andrews for assistance and cooperation in the management case study.



The term "farm structures" implies more than just a subdivision of structural design, architecture, or farm management; it denotes a separate science combining farm building design, its modification to meet various requirements, and its application to the conditions and circumstances of agriculture. (The farmstead of all-Rilco buildings in this picture is on the Stenning farm in Walworth County, Wis., owned by Daniel Peterkin, Jr.)

small owners for making improvements, and many landlords cannot justify a heavy outlay on tenant farms.

A high proportion of the most productive land is tenant operated. In some Illinois areas, for example, from one-half to two-thirds of the farms are tenant operated. Then the dwelling becomes an expense to the landlord. Questions arise concerning lease adjustments, relative benefits to be derived from buildings, division of annual expense, and determination of responsibility. An increasing number of farms are being operated by professional managers, and more and more farmers are utilizing cooperative management services.

Business records require knowledge of building costs and values. Virtually all farmers must submit income tax reports, which require information on current expense, maintenance, and capital outlay. Farm buildings must be appraised to determine values for purposes of taxation, depreciation, insurance adjustment, and valuation of estates.

Farm structures affect farm income. There are three concepts regarding the relation between farm buildings and farm income: (1) The expected returns must justify the investment, whether the returns come within the enterprise represented by the building or from the farm program as a whole. (2) Production costs may be lowered by savings in labor, reduced hazards, better equipment, or more efficient building design. (3) Output and income may be raised by meeting grade requirements, crop conditioning, or improving the quality of products.

Industrial developments create new building management problems. Most farm managers have no adequate basis for comparing building design, types of construction, and materials. But they need to know whether the value of a new development will justify its cost. Sometimes they need to decide whether to use movable or permanent construction. Movable buildings are considered chattels or personal property in contrast with fixed buildings, which are real property. Also, in using available funds, they are confronted with competition among needs for fertilizers, farm machines, and building improvements.

Long-range planning is necessary. There is a tendency to replace old structures with new ones that essentially duplicate the old, as well as to rebuild in the same location. A time lag exists between the inception of a new idea and its general acceptance. For this reason present arrangement influences the design or location of new buildings, even though the farmstead as a whole may have to be redesigned within a few years to meet new developments. Decisions must continually be made between repairing and remodeling, between rehabilitation and replacement, between new construction and abandonment, between expensive and cheap construction, and between temporary and permanent construction. A long-time plan and program is the only sound basis for making such decisions.

These concepts of farm building management as a phase of farm structures science come from many different sources and experiences. More directly, however, they are based on a four-year study of building problems on a group of 13 landlord-tenant farms. These farms are owned by the University of Illinois and managed by the College of Agriculture. Since they are not used for research, demonstration, or exhibition, each farm must justify its own management and improvement program. In this respect the farms in this group are characteristic of privately owned farms.

These farms are also typical of private farms in their variation in size, which ranges from 160 to 700 acres; in productive capacity, which ranges from low to very high, and in such characteristics as locations, type of farming, and fixed improvements. The buildings on these farms are also typical in age, number, kind, state of repair, and obvious need for modification to conform to present-day operations. On one farm, fire, windstorm, and deterioration had left only the dwelling in good condition when the farm was acquired.

The 13 farms included in the study provide the basis for the remaining facts presented here. The subject is treated in further detail in a professional thesis submitted at the University of Illinois. Only brief comments, outlines, and illustrations are given here to indicate the elements of a reasonably comprehensive program.

An objective analysis of the building problems on these farms reveals the following eight primary requisites in farm building management procedure:

Appraisal of building values. Investment values should be established, preferably on a long-time basis. Such values are needed for settling estates, for adjusting to changing ownership or management, and for use in cost accounting to make depreciation schedules and valuations for taxes and insurance. In the study of the 13 farms, engineering analyses were used in making appraisals, and these data were then reconciled with appraisals made by experienced farm managers.

Documentary record. It is desirable to establish a permanent record at the time a farm is appraised, acquired, or taken over by a new manager. This record should include such details as a land survey, size of fields, soil survey, soil conservation plan, productivity record, and historical data on production, yields, and rotations. Many of these things involve engineering. In addition, the building appraisal and farmstead plan should be a part of the record. Data on the capacity, condition, and state of repairs of buildings will also be valuable. It may be important to inspect the wiring, water supply, heating system, and other items that may be hazardous to life and property. Photographs should be used freely; aerial views of the farmstead are readily obtainable and are extremely valuable.

Plat layouts. These layouts should include plats to identify the location of the farm by section, township, and range; maps showing size and shape of fields, acreage, rotations, tile lines, contours, and soil treatment; and larger scale layouts of the farmstead, location of buildings, and identification of structures.

Projected farmstead plan. A long-range farmstead plan is needed as a guide in making plantings, in conforming to the principles of farmstead planning, and in assuring a logical plan for future improvements. Within four years on these 13 farms the projected plans have been used for locating cribs, cattle sheds, milkhouses, feeding floors, septic tanks, and fence lines.

Evaluation of present and projected facilities. Building improvements should be planned on the basis of structural condition and suitability of present buildings, cost in relation to expected use and financial returns, and fitness for proposed use. But even more important, such improvements should be evaluated in terms of the farm production program, conservation practices, land productivity, livestock-carrying capacity, and full use of the operator's time.

On one farm where nearly complete rehabilitation of buildings was required, the improvements, which cost $12,000 and added about $50 an acre in valuation, were doubly justified: (1) directly, to provide crop storage, feed floors, livestock accommodations, and better dwelling facilities; and (2) indirectly, to make possible a management system that provided for higher income, soil improvement and conservation practices, crop rotation, and more effective manager-operator cooperation.

Establishment of management policy. The kind, character, and amount of improvements to be made on a farm should be determined by the management policy. The type of farming or the system of operation is the most significant point to consider. Long-time leases may justify improvements for a special enterprise by the tenant. More money can be spent under livestock leases than under crop-share leases. Such details as size of poultry flock, the practice of crop drying, or ownership of tools and utilities will affect certain improvements. The standard of housing set by the owner-operator for his family or the housing provided by the landlord on tenant farms must be defined before a complete building program can be determined.

Long-range plan. Consistent and economical farm-building management must be based on a long-range plan, projected perhaps 10 years ahead. Such planning will avoid expensive repairs to buildings that *(Continued on page 70)*

Equipment and Procedures for Farm Tractor Tire Studies Under Controlled Conditions

By I. F. Reed and M. O. Berry

MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

AVAILABLE information indicates that the first pneumatic tires used on drivewheels of a farm tractor were field tested in April, 1932. They were 6-ply, 11.25x24 tires designed especially for use on the largest bomber built up to that time. Since the plane was wrecked on its first flight, the tire manufacturer was looking for a place to use the tires made up for it. These field tests indicated some of the possibilities and values of pneumatic tires on tractors. The first pneumatic tires designed especially for use on tractors were made available three to four months later. The use of this type of tire has made possible the light, higher speed, efficient tractors of today. Now pneumatic tires are considered standard equipment on most agricultural tractors. This position was not gained without a fight against conventions, overcoming imagined shortcomings and design difficulties, and other problems. Some of the early work on tire testing is reported by McKibben, Davidson, and others in AGRICULTURAL ENGINEERING during 1939 and 1940.

Tread designs on tires for traction, like those used on the early automobile tires, followed the whims of the designer. Horseshoe, ribbed, button, cleated, and other types of treads were tried until, through the process of elimination, most tire manufacturers have an angle lug of some form as a part of their design. Many conflicting claims were made as to the value of design features that might or might not have a direct bearing on tractive efficiency. This was due no doubt to the fact that it was not possible to control soil and operating conditions accurately enough in the field to measure the exact value of these features for different soil conditions.

The facilities of the USDA Tillage Machinery Laboratory*[1 2 3] at Auburn, Ala., provide means of controlling these soil and operation variables that have plagued the engineer making tests in the field. Ten selected soils varying from sand through several phases of loams to a heavy clay are in the bins. These soils can be put into and maintained in almost any desired condition by use of the subsoilers, subsurface packers, leveling equipment, flat roller, sprinkling equipment, and movable covers available for that purpose. This soil-fitting equipment and especially designed test equipment are all mounted in cars that operate on the plot rails so that only the soil-fitting tool or the unit under test touches the plot soil. Thus all unnecessary soil packing due to transport wheels is avoided. Therefore, the tests are conducted in or on a uniformly prepared level soil with the test unit supported in a framework that is carried in a plane parallel to the soil surface, as compared to conditions necessarily encountered in the field.

The possibility of studying the effect of tractor tire design factors under the controlled conditions of the Tillage Machinery Laboratory were considered several times during the period from 1935 to 1941. A proposed tire test project was prepared and preliminary plans made for the needed test equipment. The program was not activated due to indicated costs. However, a short study was made in 1939 to obtain an indication of the relative packing effects of different types of traction units. These tests, as reported by Reed[4], showed quite definitely that rubber tires tend to compact a layer of the soil more than steel wheels or tracks do. They show also the suitability of the Tillage Machinery Laboratory setup for comprehensive studies of factors in traction unit design and their relation to traction and the conditions set up in and on the soil. The war prevented further consideration of the development of a traction test program until 1946.

When it was indicated that it was going to be difficult to develop a coordinated tire and traction study with representatives of the major tire manufacturers as a group, representatives of the United States Rubber Company began considering the possibilities of going ahead with the study. Their first interest was expressed in 1940, but war work prevented progress in developing the program until 1946. Real development of the needed test equipment began when J. W. Shields of the Company visited the Laboratory in April, 1946. The basic specifications for the unit were worked out at that time and the test equipment to be discussed later in this paper was designed and built under Mr. Shield's direction. When it became apparent that the tire test unit could not be completed for use during the 1947 season as planned, preliminary tests

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Power and Machinery Division.

I. F. REED and M. O. BERRY are, respectively, senior agricultural engineer and assistant agricultural engineer, division of farm machinery (BPISAE), U. S. Department of Agriculture. (U. S. Tillage Machinery Laboratory, Auburn, Ala.)

AUTHOR'S ACKNOWLEDGMENT: The authors are indebteded to J. W. Shields and Tom Brown of the United States Rubber Co. The work reported was done under a cooperative agreement with this company to study basic design features of farm tractor and implement tires in different soils under various operating conditions.

*Superscript numbers refer to appended references.

Fig 1 *(Left)* Tractor hitched to power car for tire tests. The load is shown by the dynamometer gage on the tractor and recorded by the power car dynamometer • Fig. 2 *(Right)* Making a tire test using laboratory dynamometer. The man at the left controls the loads, and the man on the right is setting a pin to mark distance. The lines on the soil are to guide the tractor driver

Fig. 3 Tread designs on eight of the eleven tires studied

were made using the Laboratory dynamometers and other available equipment.

The 1947 Tests. These tests were made to obtain information on the relative performance of different models of tractor tires. They were designed to enable comparing tractive effort, slippage, and other factors under uniform conditions of load, soil condition, etc. A three-plow, tricycle-type tractor was used for the power unit. The rear wheels were adjusted to 72-in spacing to obtain most economical use of the plot and were loaded to 2,185 lb each, the recommended load for an 11.00x38 tire. The tractor was hitched to the power car dynamometer through an indicating-type dynamometer and chain arrangement as shown in Fig. 1. The gage on the indicating dynamometer was marked and so located that the man operating the power car brakes could see these markings so as to apply and hold the desired loads. A test consisted of two revolutions of the tire. One revolution was allowed between tests for changing the load. This permitted applying six progressively increasing loads while going the length of a plot. The tires were marked and pins set at the beginning and end of each test, as shown on Fig. 2, to enable measuring the distance traveled for that load. The difference between this distance and the rolling circumference of the tire gave the amount of slip. Performance curves for the tires studied were made by plotting distance traveled against load. These tests were made with the tractor in first gear and at full throttle.

Ten 11.00x38 tractor tires were used in this study. Tire No. 8 is a modification made of tire No. 7 to improve its performance. Eight of the tires used are shown in Fig. 3; however, there is no relationship between the arrangement of the tires in Fig. 3 and in Table 1. As only two to four sets of tires could be used in a plot without refitting the soil, one tire was included in each group of tires tested. It was rated as 100 per cent and was used as the "base" for comparing the tires. This tended to eliminate any effects due to slight variations in soil conditions and other factors. The per cent drawbar load, based on No. 1 as 100, of each tire pulled at 16 per cent slip in the several soils is shown in Table 1. These data show that the drawbar load a tractor could handle under the soil conditions studied was affected as much as 10 per cent in the sand and 14 per cent in the loam and clays by the design of the tractor tire tread. The effect of tread design is particularly shown by comparing the data for tires Nos. 7 and 8. Tire No. 7 was supposedly a superior model, but the tests showed it to be much lower on the scale than the older model it had replaced and less effective than the "base" tire. Tire No. 8 is a laboratory modification of tire No. 7. The change made here increased the load it would handle by 3 per cent in the sand and 6 per cent in the loam.

Data comparing five tires in two soils are shown in Fig. 4. These curves show the load distance traveled per revolution of the wheels and per cent slip for these tires through the range of loads used. It is possible to compare not only the slippage at a selected load but also to determine the relative distances traveled by two tires handling the same load. For example, tire No. 9 traveled 12.57 ft per revolution, pulling 2,200 lb in loam, but tire No. 7 traveled only 12.17 ft under the same conditions. This is important to the user as it indicates that a tractor operating at selected speed and pulling this load would travel 0.40 ft farther per revolution of the rear wheels if equipped with the No. 9 tire. This would enable doing 3.3 per cent more work at no additional cost.

The U. S. Rubber Co. Tire Test Unit. The 1947 study and earlier tests proved definitely that the facilities of the Tillage Machinery Laboratory readily lend themselves to the study of tires for transport or traction purposes. It was found that data obtained were consistent. However, using a tractor for the power unit made it necessary to use a pair of tires rather than a single tire and to use part of the plot area for the front-wheel track. This limited the runs that could be made in a plot to four without having to refit the soil. This would permit comparing only two tires if duplicate runs were made. The tire test unit shown in Figs. 5, 6, 7, and 8 is designed to give much more accurate results and enable making duplicate runs on five tires in a plot. Since six loads can be used in the length of a plot, the duplicate runs give twelve points on the curve for each tire.

The tire test unit consists of a tractor for driving the test tire, dynamometers for measuring the power input and output of the tire, a loading device, distance-measuring equipment, and recording equipment, all mounted in or on a suitable car designed to operate on the plot rails. The method of applying and measuring the loads is shown in the schematic diagram, Fig. 8. The torque of the tractor engine is delivered to the tire through the torque dynamometer mounted in the

TABLE 1. RELATIVE DRAWBAR LOAD EACH TIRE PULLED IN EACH SOIL CONDITION USING TIRE NO. 1 AS 100 PER CENT

	Per Cent Drawbar Pull at 16 Per Cent Slip			
Tire No.	Norfolk Sand	Davidson Loam	Cecil Clay	Decatur Clay
1	100	100	100	100
2	99	105	104	
3	109	100		
4	97	111		
5	102	103		113
6	109	104		103
7	99	97		100
8	102	103		
9	99	107		103
10	92	101		
11	102	101	99	

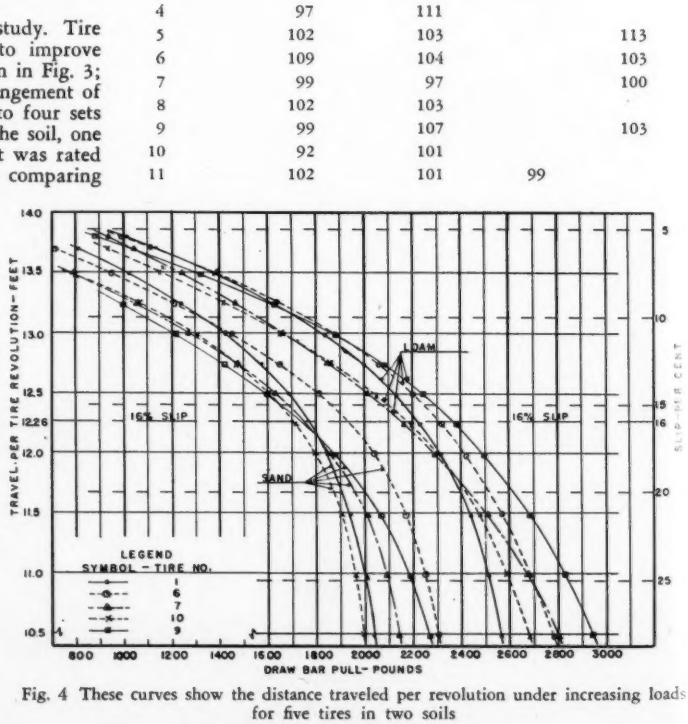


Fig. 4 These curves show the distance traveled per revolution under increasing loads for five tires in two soils

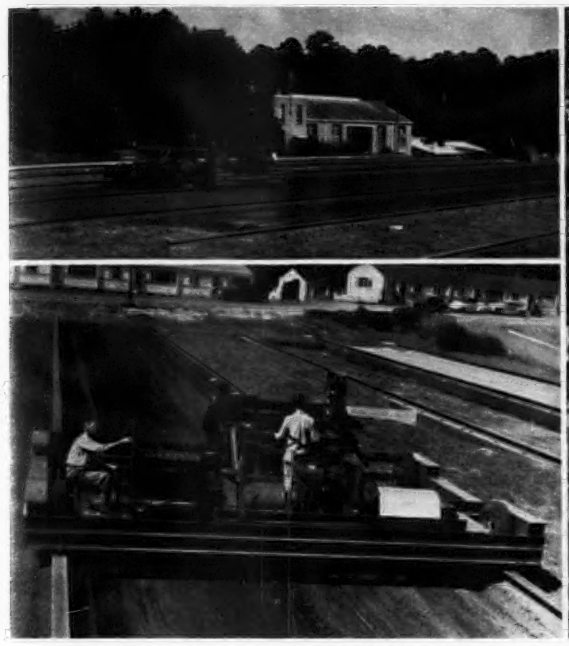


Fig. 5 *(Upper left)* The tire test unit in use at the USDA Tillage Machinery Laboratory • Fig. 6 *(Lower left)* The tire test unit. The man on the left controls the loads and operates the recording camera. The other man stops and starts the unit and controls the engine speed. The automobile engine is used for moving the car when not being used for tests • Fig. 7 *(Right)* A view of the instrument panel and dynamometers. The movie camera for recording the data is in the upper right-hand corner. Connection to the torque dynamometer is shown in the hub of the wheel

hub of the wheel and is indicated on the gage marked "TM" on the instrument panel, Fig. 9. The tire grips the soil and tends to move forward, carrying the test car with it. The force required to move the car is measured by the drawbar dynamometer and is indicated on the top gage. The load on the test tire is controlled by the several adjustments on the rheostat in the electric dynamometer circuit. The power absorption unit is driven from the two rear wheels of the test car as shown.

A six-cylinder farm tractor is used to drive the test tires. It is mounted in the superframe of the test car with the front end resting on an anti-friction bearing mounted support so that it is free to move forward or back, but not sidewise or to rotate. The drawbar dynamometer shown in Fig. 7 prevents the tractor from moving forward in the frame. The tractor differential is locked and the right axle removed so that the unit has only a bevel gear drive for transmitting the engine power to the wheel. Adjustments enable raising or lowering either the front of the tractor or the dynamometer hitch to suit operating conditions. The rear of the tractor unit can be raised in the superframe to permit moving the superframe crosswise in the test car.

The distance traveled is indicated on the counter marked "B" on the panel, Fig. 9. This unit shows one count for each 1/30 of a revolution of a bicycle wheel operating on the plot rail. The counter marked "T" indicates revolutions of the

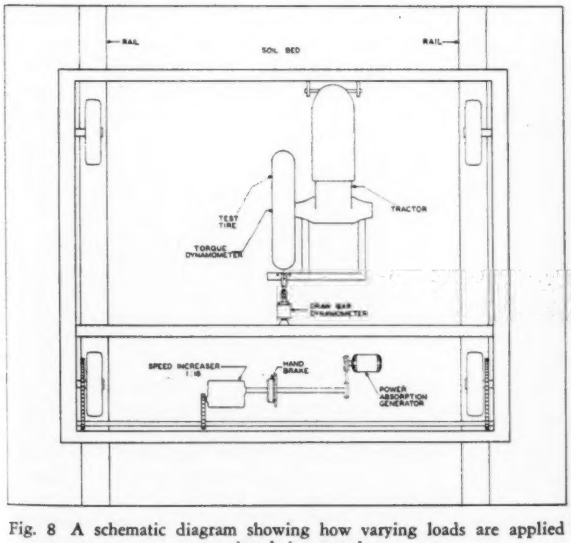


Fig. 8 A schematic diagram showing how varying loads are applied to tires being tested

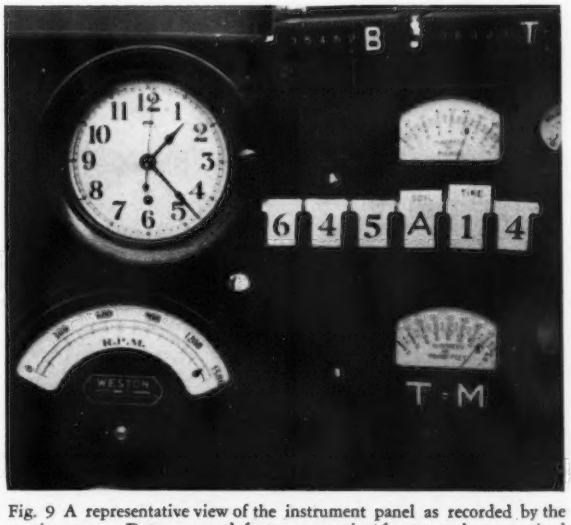


Fig. 9 A representative view of the instrument panel as recorded by the movie camera. Data are read from progressive frames and summarized

tire under test. It counts 41.85 times per tire revolution. Thus one counter indicates the distance the tire traveled, and the other gives the information necessary for determining the distance it should have traveled. Lights flash on the instrument panel to indicate the revolutions of the tractor wheel. The speed of the tractor engine is shown by the tachometer and time is shown by the clock. Simultaneous recordings of all instruments and gages are made by use of the 16-mm motion picture camera shown in Fig. 7 (near the operator's face). This camera makes 16 readings of the instrument panel per second. Fig. 9 shows the reading on one frame of the record. The data from a series of these frames show torque in the wheel, drawbar load, time, engine speed, distance traveled, revolutions of test tire, test number, soil, and the track in which the test was run. Assembled data from these records give information for plotting the relationships as shown in Fig. 4 for the 1947 tests and the curves shown in Figs. 10 and 11. Similar data will be especially valuable in evaluating tread design factors when obtained for tires in which only one design factor is varied.

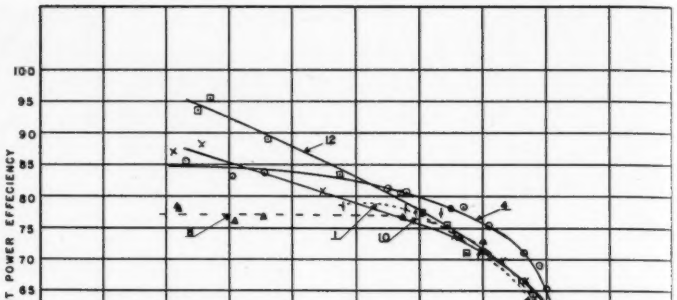


Fig. 11 Curves showing power efficiency plotted against load for the same five tires shown in Fig. 10

The tire test unit discussed here enables making a complete draft, slippage, and efficiency study of a tire while operating only two revolutions. Load changes can be made in one revolution of the tire. This permits testing a tire under six progressively increasing loads while traveling the length of a soil bin. It is possible to have 11 test tracks per bin by spacing them 18 in apart. Duplicate runs can be made on five tires, leaving one track for reserve. The work is so organized that a three-man crew can make duplicate tests on five tires in three soil types in less than 3 hr. This gives a total of 180 individual tests. Series of tests are made in as short a time as possible to reduce the change in soil conditions to a minimum. An analysis of the probable errors in data obtained shows the probable maximum error to be less than 2 per cent and the probable average error to be less than one per cent. This test unit and available production and special test tires will enable:

1 Evaluating tire tread design features as factors in promoting effective traction in different soil conditions

2 Determining the effects of soil and soil conditions on traction and rolling resistance of tires for agricultural implements

3 Measuring the effect of tire load, design, and operating factors in and on the soil when used for either traction or transport.

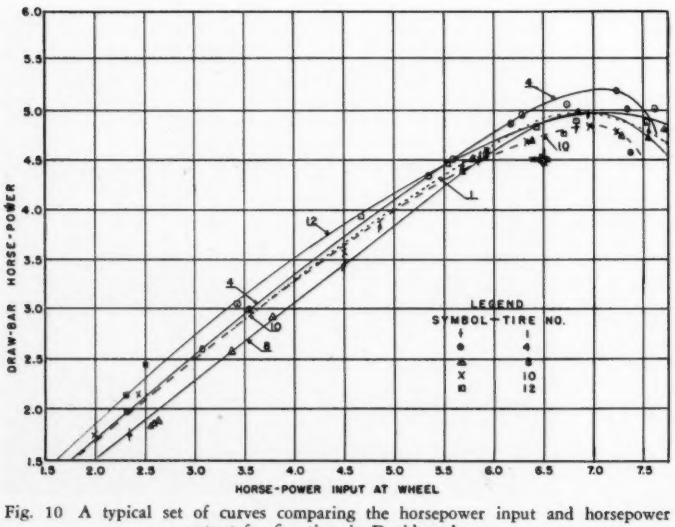


Fig. 10 A typical set of curves comparing the horsepower input and horsepower output for five tires in Davidson loam

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Farm Building Management

(Continued from page 66)

should be demolished, discourage temporary expedients, and enable the farmer to work toward a long-time objective. In addition it will permit him to distribute his capital investment over a period of years; defer or speed up the program according to resources and economic conditions; prevent him from incurring unusual expenses at any one time; and make it possible to set goals that will be acceptable to both owners and tenants.

The outline for a long-range plan is extremely simple. It includes tentative or possible dates for each activity. In it buildings or improvements are scheduled for (1) demolition and abandonment, (2) replacement, (3) additions, (4) emergency repairs, (5) permanent repairs, or (6) reconditioning and remodeling.

Structures planning. Engineering services should be used in preparing original building plans or in modifying standard plans for building improvements. If professional service is available, it may well be utilized not only for building plans and technical consultation, but for soil and water engineering as well. Although most farm owners and managers direct their own improvements, and always make final decisions, agricultural engineering service can usually be justified in terms of providing better functional values and safeguards and more economical installation and operation. Such service is being used increasingly as an adjunct to professional farm management.

An Adaptation of Drying Corn with Forced Air

By David B. Poor

MEMBER A.S.A.E.

THE HUGE corn crop this year offered a great challenge to the handling of corn in storage. Farmers, besides wanting to keep corn without spoilage, wanted to be able to qualify for government loans.

Most designs of corn cribs for natural ventilation and drying of corn were made back in grandfather's day. In those days corn was usually dried in the shock in some areas and was dry by the time it was placed in the crib. When husking off the stalk was done, one or two men would pick about the same amount of corn in the same number of days as it now takes one or two-row pickers to pick in hours. Present-day corn pickers have shown the old corn crib design inadequate for rapid filling, especially when the corn is dirty. In other words, we are using middle 20th century harvesting methods with 19th century storage buildings. Another problem is that the standard old-fashioned corn crib is a single-purpose building — it stands empty and useless much of its life.

The Solution. A modern corn storage building, designed to work with modern pickers, and still be suitable for other uses, is needed for profitable corn storing. The solution is the use of one-story, clear-span buildings with drying facilities. Soft corn can then be handled. Drying facilities give these benefits:

1 Corn can be picked earlier because the crop can be put in storage with a higher moisture content. Thus advantage can be taken of the good weather in early fall.

2 Less corn is left in the field by early picking and also there is less shelling.

3 The husking rolls do a better job before the husks are completely dry.

4 The moisture content can be controlled, so spoilage can be prevented.

5 When it is wanted to follow corn with wheat, sowing can be done to better advantage after early picking.

Because it recognized the advantages of using drying facilities and because of the great need for corn storage buildings, our company decided to produce a corn storage building including drying facilities.

In producing this corn-drying building, many agricultural engineers and corn storage authorities in the U. S. Department of Agriculture and the state agricultural colleges were consulted.

After considerable investigation, our company decided that the Quonset 32 was a "natural" for a corn storage building using forced air for drying. The reasons for this decision were as follows:

1 The Quonset is of one-story, clear-span construction so that it can be used for purposes other than corn storage, and it is available in a variety of lengths. Therefore, if a farmer does not have enough corn to fill the building, he can use the unfilled part for something else. In other words, he can buy any length of Quonset he desires and he can use as little or as much of it for corn storage as he needs. The remainder of the building can be used for such things as grain storage, implement storage, hay storage, or livestock shelter.

2 Moreover, this type of construction is economical. The weight of the corn or stored materials is all on the ground. There is no heavy and expensive construction to hold tons of weight in the air. This means lower storage cost per bushel.

3 This type of building is adaptable for drying corn with only minor structural changes. Air distribution is good because the thickness of the corn pile through which air flows is approximately equal in all directions.

4 These buildings were already available and in quantity production, so the farmer received the benefit of the many other uses for Quonsets.

5 Considerable research had already been done on similar types of buildings. Storing corn in the Quonset is similar to the use of the conventional double crib where corn is placed in the center driveway. In many sections of the country it is now becoming common practice to dry corn with these arrangements.

6 After two seasons of use, Quonset buildings have proven to be very practical and economical for wheat and other grain storage.

Although it was believed that the idea was technically good and supported by years of research by the U. S. Department of Agriculture and the state agricultural colleges, it was realized that considerable educational work would be required to convince farmers of its advantages. Also, it was known that the basic unit, a Quonset 32 ft wide and 36 ft long, holding 5000 bu was somewhat large for the average farmer. Nevertheless, the most critical need was that of the big grower, and it would provide a starting point.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a joint contribution of the Farm Structures and Rural Electric Divisions.

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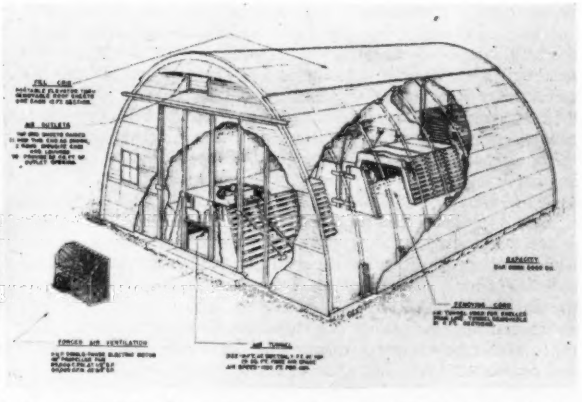

Fig. 1 *(Left)* A Quonset 32 adaption for corn curing and storage . The fan shown, driven by a 5-hp motor, forces air through the stored corn. The removable bulkhead above the fan and door assembly permit using the building for other purposes when emptied of grain *(Right)* A Quonset 32x36-ft corn-drying and storage building. Type A is furnished with standard Quonset rib construction plus floor-to-rib bracing at the sidewalls. Type B is furnished with double-rib construction without floor-to-rib bracing at the sidewalls. The interior furnishings are removable

Fig. 2 *(Left)* Interior view of a Quonset 32-A for corn drying and storage. • Fig. 3 *(Right)* Corn is loaded into a structure through removable roof sheets. The capacity of this building is 5,000 bu of ear corn

Description. The building used for forced air drying is either a standard type A or type B Quonset building, which is a clear-span, semicylindrical steel building with 16-ft inside radius ribs (Fig. 1). This gives inside measurements 16 ft high and 32 ft wide. The Type A building has ribs spaced 4 ft on centers, while the Type B has two ribs together, spaced 4 ft on centers. To take care of lateral pressure, the Type A building has to have sidewall braces, while both types require endwall braces. After deducting space for the air tunnel, a 36-ft-long building will give a capacity of slightly over 5000 bu.

It was decided that forced air without heat would be used, as this system had already been proven successful in corn drying. The heated air system for curing corn stored in such large amounts was considered not far enough out of the experimental stage to be commercially justifiable at a reasonable equipment expense to the farmer. However, heated air can be used for drying corn in the Quonset building just as well if not better than with any other building.

A limiting factor in any fan installation is that many rural electric lines have a load limit factor of 5 hp for any electric motor. Some 42-in propeller fans with 5-hp motors will deliver around 25,000 cfm of air at ½ in pressure. For unheated air, corn storage authorities state that there should be 5 to 10 cfm per bu. When the building is full, 5000 bu, the minimum requirement of air is met with a 25,000-cfm fan. However, the fan is usually turned on as soon as there is enough corn in the building to give effective air distribution, so most of the time there is more than the minimum amount of air per bushel.

A 5-hp motor and a 42-in fan are supplied as regular equipment for each Quonset 32x36-ft corn storage. Buildings of 48 ft to 72 ft in length require two fans, one at each end.

The air tunnel (Fig. 2) is built of wood and has a cross-sectional inside area of 25 sq ft which, with a 25,000-cfm fan, will mean an air velocity of 1000 fpm, which is also the common recommendation. The tunnel is built in removable 4-ft sections so that, as corn is taken out, the tunnel sections can be removed so that the floor space can be used for something else, if necessary, thus providing for flexibility of building use.

The standard Quonset endwalls have 12x12-ft outside sliding doors. So that flexibility of use is retained, and these doors are standard equipment on the corn storage building. The door openings are then fitted with easily removable bulkheads built of steel studs with corrugated steel sheets on the inside. When the bulkheads are removed, the endwall doors can be used as in the standard Quonset building. For those few farmers who would not desire the standard endwalls with 12x12-ft doors, solid endwalls are available.

The fan is located outside the building and is attached to the bulkhead studs which are 48 in on centers. Two inside sheets are left off at the bottom of the bulkhead where the fan is located, so there is an opening about 46 in square for attaching the fan. By using four 2x4's to fill in between the steel studs, and by using mastic to fill the cracks, an airtight connection between the fan and the building can be made by bolting the fan to the bulkhead studs.

Filling the building with corn can easily be done with a portable elevator by removing a few roof sheets on the top (Fig. 3).

Corn is taken from the building either through the ventilating tunnel which is in removable sections or through shelling trenches and drag lines. In starting the removal through the tunnel, a series of louvers in the endwall just over the tunnel permits the farmer to get out enough corn so that the loose slats on the tunnel can be taken out.

Air which the fan puts into the buildings must come out. The Quonset plans show that the bottoms of the galvanized sheets at the top of the endwalls are tipped outward for the removal of moisture-laden air.

Specifications call for a concrete floor over a moisture barrier to prevent soil moisture from working up through the concrete. Corn can then be placed directly on the concrete floor.

To prevent corn from pushing directly against the inside of the outside steel covering and to provide an air chimney for the air to get out from the edges of the corn piled around the sidewalls, an inside lining of wire mesh or 12-in wide corrugated sheets, placed 1½ in apart, is nailed to the inside of the ribs. Fig. 4 shows an outside sheet cut away so that the inside sheets are visible. The fluttering ribbons show the effectiveness of the air distribution.

Results to date. The results to *(Continued on page 77)*

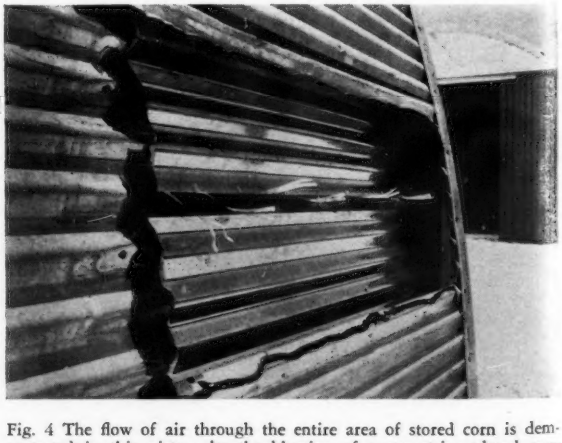

Fig. 4 The flow of air through the entire area of stored corn is demonstrated in this picture by the blowing of paper strips placed over a cutaway section of sidewall. Air flowing through the corn normally leaves the building through louvers and vents at the top of each endwall

Reservoir Sedimentation in Limestone Sinkhole Terrain

By Gunnar M. Brune

THE PURPOSE of the study reported in this paper was twofold. First, it was desired to determine the amount, character, and distribution of the sediment that is filling Spring Mill Lake, Mitchell, Indiana, at such an alarming rate; the sources of this sediment; and possible remedial measures which might be employed to reduce the damage. Second, information was desired as to rates of sediment production which might be expected in the Highland Rim physiographic province, in which this reservoir watershed lies. Very few sediment records have been gathered in this physiographic area.

The Dam and Reservoir. Spring Mill Lake is located on Mill Creek in Lawrence County, Indiana. It is four miles east of Mitchell, in Section 33, Township 4 North, Range 1 East. Its backwater extends into two principal tributaries, Mill Creek and Hamer's Creek (Fig. 1). Lying in Spring Mill State Park, it is used as a recreational lake, for swimming, boating, and fishing.

The reservoir was created by a dam 360 ft long and 19 ft high above the original channel. It is earthfill, with slopes of 3.5 to 1 on both sides. A concrete spillway is located at the north end of the dam, at an elevation of 603 ft above mean sea level (USGS datum).

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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When storage began in October, 1938, the surface area of the lake was 28.0 acres and the storage capacity 178 acre-feet. The dam was built by the Indiana State Conservation Department with the assistance of the National Park Service and Works Progress Administration, at a cost of approximately $25,000, including the cost of the land, clearing, sanding of beaches, and construction of the dam.

The lake is small in relation to the size of its drainage area (15.03 sq mi). It had an original capacity per square mile of drainage area (C/W ratio) of only 11.8 acre-feet.

Sedimentation in the Reservoir. In measuring the original capacity of the reservoir and the volume of sediment deposits, a detailed-reconnaissance sedimentation survey was made. Sixteen ranges were laid out so as to obtain representative cross sections from all parts of the lake. On these ranges 67 measurements were made of sediment and water depth, using a spud or soil auger and copper-cored sounding line.

The spud, when dropped through the water, goes through the sediment deposits and into the underlying old soil. Each groove retains a sample of the deposit at the point at which it comes to rest. Clear distinctions could be made almost everywhere in Spring Mill Lake between sediment and old soil. The old soil or channel bed was nearly always of decidedly different texture, structure, or color than the recently deposited lake sediment.

In areas where the lake has been filled with sediment above spillway crest, the depth of sediment above the old soil was determined with an extension soil auger. A level was used to determine what part of the sediment at each point was above spillway level.

This type of survey is very similar to a detailed sedimentation survey. The ranges were located in the same positions as for a detailed survey. The cross-sectional area of sediment or water on each range was determined. The formulas developed by Brown and Eakin (pp. 158-161)[2]* were used in computing sediment volumes. The survey differed from a detailed survey only in that instrumental control of position from the shore was not used. Instead, the boat was kept on the range by lining up two trees or other objects on the shore, measurements were spaced at approximately equal intervals across each range, and the water surface, corrected to spillway level, was used as a datum for elevation. This type of survey is believed to be accurate within 5 per cent of the results which would be obtained by a detailed survey.

The results of the survey are summarized in Table 1. In the period of 9.9 years since its construction, the surface area of the lake has been reduced by 2.8 acres, or 10.0 per cent. Its capacity, on the other hand, has been reduced by 28.8 per cent, from 178 to 127 acre-feet. The annual loss of storage capacity has averaged 2.91 per cent.

Fig. 1 shows the distribution of sediment deposits within the lake. Above-crest deposits are encroaching upon the lake in three arms. These are not, strictly speaking, delta deposits, since they have no steep foreset beds, but rather slope gradually down into the water. It will be noted that the upper portions of the lake have become very shallow, having lost nearly all of their capacity to sediment. There is a progressive decrease in the percentage of storage lost from segment K where 93 per cent has been lost to segment A where 9 per cent has been lost.

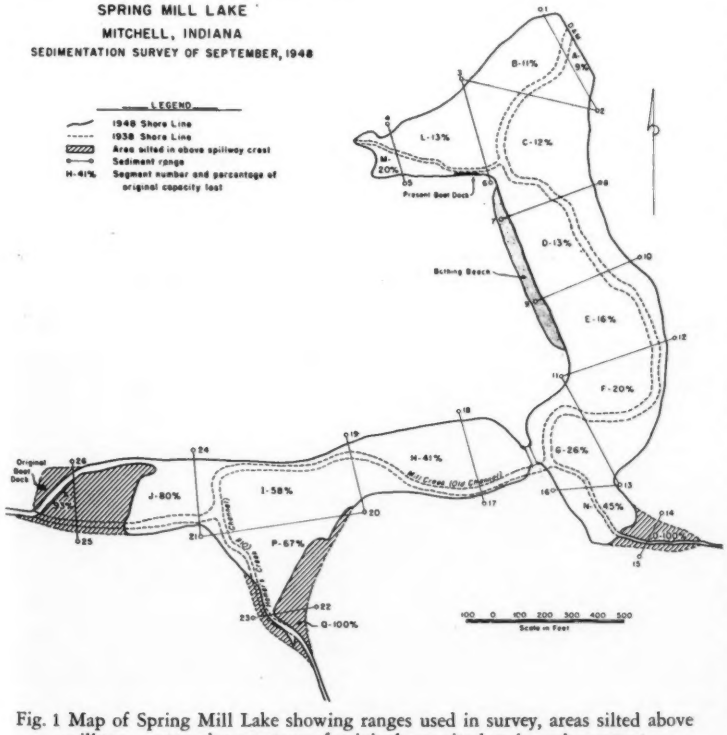

Fig. 1 Map of Spring Mill Lake showing ranges used in survey, areas silted above spillway crest, and percentage of original capacity lost in each segment

*Superscript numbers refer to appended references.

The sediment consists chiefly of poorly compacted silt and clay, ranging in color from gray in submerged areas to brown or rust where recently exposed to the air. Practically no sand is present. Nearly all the sediment is silt, with some clays in the lower part of the lake. Using data developed by Lane and Koelzer (pp. 49-50)[7], and assuming that 85 per cent of the sediment is silt and 15 per cent clay, the average density of the reservoir sediment was computed to be 67 lb per cu ft.

Effects of Sedimentation. As shown in Fig. 1, the boat docks were originally located at the upper end of the lake. Within a few years, because of sedimentation, it was necessary to move them to their present location near the dam. Fishing in the lake is poor, because the more desirable species of game fish cannot survive in water of such high sediment concentration. It is quite obvious that the new sediment deposits are being deposited progressively farther and farther down the lake. It is also apparent that the sediment is not being trapped to any appreciable extent in the upper part of the lake by the bridge across its middle. This is shown by the fact that there is no sharp drop in the percentage capacity lost below the bridge as compared with that above the bridge. Rather, there is a uniform decline from the upper end of the lake to the dam. If a considerable part of the sediment were coarse material, the constriction at the bridge might slow the velocity of the water in the upper part of the lake sufficiently to cause much sediment to settle out. As it is, however, the sediment is chiefly fine material, which is carried in suspension and requires a long period of time to settle. The constriction at the bridge will not be a barrier to this type of sediment.

Since the lake has lost almost a third of its capacity in 10 years, it is not difficult to predict that in 10 more years, if present conditions are allowed to continue unchecked, serious difficulty will be encountered in maintaining the bathing beach because of deposits of mud encroaching upon it. Twenty years from now the lake will become useless for recreational purposes.

The lake is of course not the only attraction at Spring Mill State Park. There is the old grist mill and village, and the caves into which boat trips may be taken. The loss of the lake would, however, seriously impair the attractiveness of the park for recreation.

Character of the Watershed. The watershed of Spring Mill Lake is comprised of 15.0 sq mi in the Highland Rim physiographic province, in Lawrence and Orange Counties in southern Indiana (Fig. 2.) The underlying rocks of the area belong to the Meramecian Formation of the Upper Mississippian Period. The predominant rocks are the St. Louis and St. Genevieve limestones, which are very susceptible to the formation of underground channels, caverns, and sinkholes. As a result, nearly all the watershed, except the southeastern tip, has abundant sinkholes.

These sinkholes may be lumped into two categories, closed and open. The closed sinkholes may be further subdivided into two classes, (1) those which are effectively sealed and which pond water (Fig. 3) but contribute neither water nor sediment to the underground drainage and the reservoir downstream, and (2) those which are closed by colluvial deposits but not sealed tightly enough to pond water (Fig. 4). These contribute water, but not sediment, to the underground drainage system and reservoir. The open sinkholes (Fig. 5), with which we are chiefly concerned from the standpoint of sedimentation in the reservoir, provide an opening through which surface runoff, with its entire sediment load, can pass directly into the underground channel system.

With the aid of a preliminary draft of the Mitchell, Indiana, topographic quadrangle, prepared by the U. S. Geological Survey, stereoscopic study of aerial photographs, and personal inspection of the watershed, the author was able to outline the areas covered by closed and open sinkholes as shown in Fig. 2. It was found that the open sinkhole, or sediment-contributing portion of the watershed, comprises 5.29 sq mi,

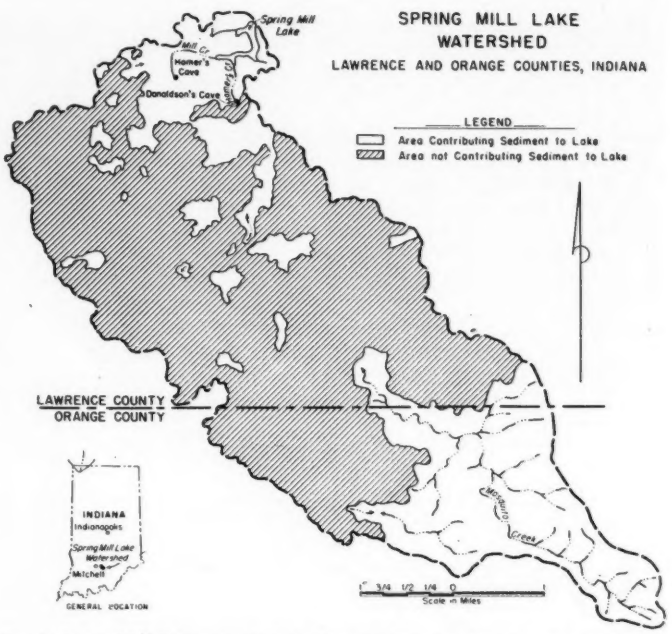

Fig. 2 Spring Mill Lake watershed showing sediment-contributing and non-sediment-contributing areas

TABLE 1. SUMMARY OF SEDIMENTATION DATA

	Quantity	Unit
*Age** (1938-1948)	9.9	Years
Watershed		
Sediment-contributing portion	5.29	Sq mi
Non-sediment-contributing portion†	9.74	Sq mi
Total area†	15.03	Sq mi
Reservoir		
Area at spillway stage:		
1938	28.0	Acres
1948	25.2	Acres
Storage capacity at spillway stage:		
1938	178	Acre-feet
1948	127	Acre-feet
Capacity per square mile of drainage area:		
Total drainage area —		
1938	11.8	Acre-feet
1948	8.4	Acre-feet
Sediment-contributing portion —		
1938	33.6	Acre-feet
1948	23.9	Acre-feet
Sedimentation		
Total sediment:		
Below spillway crest	51.1	Acre-feet
Above spillway crest	0.8	Acre-feet
Total	51.9	Acre-feet
Average annual accumulation:		
From entire drainage area	5.25	Acre-feet
Per square mile —		
Of sediment-contributing drainage area	0.99	Acre-feet
Of total drainage area‡	0.35	Acre-feet
Per acre of sediment-contributing drainage area	2.26	Tons§
Depletion of Storage Capacity		
Per year	2.91	Per cent
Total	28.8	Per cent

*Storage began October, 1938. Date of survey was September 1-2, 1948.

†Including area of lake.

‡Excluding area of lake.

§Using an estimated dry weight of sediment of 67 lb per cu ft.

while the closed sinkhole, or non-sediment-contributing portion, comprises 9.74 sq mi.

Inspection of Fig. 2 will show that the main tributaries which feed the lake, Mill Creek and Hamer's Creek, issue from two caves in the limestone bluffs, Hamer's Cave and Donaldson's Cave, respectively. The water which issues from Hamer's Cave drains from the western portion of the watershed, while that which issues from Donaldson's Cave drains from the eastern portion. The large area in the southeastern portion of the basin drained by Mosquito Creek is comparatively free of sinkholes, but drains into several large sinkholes just north of the Lawrence-Orange County Line.

Mill Creek always becomes muddy after a rain in the western part of the watershed, while Hamer's Creek always becomes muddy after a rain in the eastern part. Sediment concentrations usually reach higher values in Hamer's Creek, however, because of the larger proportion of open sinkhole area in the eastern part of the drainage area. The underground channel from the large sinkholes just north of the county line to Donaldson's Cave is large enough for a man to pass through, and has been explored from end to end.

A detailed study was made of the open sinkhole, or sediment-contributing portion of the watershed. The topography ranges from rough in the north, immediately adjacent to the lake, to gently undulating in the southeast corner. Slopes range from 50 per cent around the lake to 5 per cent in the southeast portion. The higher parts of the watershed are about 300 ft above the lake.

In the rough, northern part of the watershed, the most common soil type found is Orleans silt loam, which is usually severely eroded. Frederick silt loam, a well-drained soil with reddish subsoil, and Bedford silt loam, with fair drainage and a yellow subsoil, are found on more moderate slopes in the central part of the watershed. All of these soils rest on acid, cherty, red, waxy clay substratum, with hard limestone 10 ft below the surface. In the southeastern part of the basin is found some Lawrence silt loam, an imperfectly drained soil.

A sampling study showed that in the sediment-contributing portion of the watershed, the land use is 16.3 per cent clean-tilled, 17.2 per cent small grain, 16.8 per cent hay, 16.7 per cent pasture, 15.0 per cent woods, 7.9 per cent farmsteads and urban, and 10.1 per cent idle. This is an area of low agricultural productivity. The high percentage of idle land is significant.

The heavy-textured soils found in this watershed have a low permeability and are very vulnerable to sheet erosion, particularly when cultivated on steep slopes. Sheet erosion from straight-row farming of clean-tilled crops and small grain was found to be severe. Much idle land also has been left without proper cover and is suffering serious sheet erosion. Gully erosion is also serious. Stream-bank and roadside erosion are of minor importance. Ditching of upper Mosquito Creek has contributed some sediment. It is estimated, on the basis of this and other studies in this region, that about 90 per cent of the sediment filling the lake originates from sheet erosion on cultivated and idle land, mainly corn and wheat fields on slopes of 5 to 30 per cent. About 5 per cent is derived from gully erosion and 5 per cent from stream-bank, channel, and roadside erosion.

REMEDIAL MEASURES

Excavation or Dredging. Small reservoirs such as this one, when they fill up with sediment, are sometimes drained and the sediment excavated with a power shovel or dragline scraper and dump truck. In other cases, the sediment is removed with a floating suction dredge. As has been ably stated by Brown, Stall, and DeTurk in their study of Lake Decatur (p. 52)[3], it is obvious that the removal of one cubic yard of sediment from the lake by excavation or dredging will provide only one additional cubic yard of storage capacity. The movement of a cubic yard of earth, however, for raising the present dam or building another dam, might be expected to furnish as much as 50 cu yd of storage. Therefore, excavation or dredging compares very unfavorably with the cost of new reservoir construction.

Dredging also creates the problem of disposal of the dredged material. Flat lands on which materials could be deposited are not available near the reservoir. Deposition of excavated or dredged material in locations where it would wash back into the lake would represent a waste of effort and funds. The present-day cost of dredging or excavating a small reservoir of this type is about 50c per cu yd, or $807 per acre-foot, of sediment removed.

Raising the Dam. If the dam and spillway were raised 3 ft, the storage capacity of Spring Mill Lake would be increased by approximately 100 acre-feet. Such a rise in the lake level would, of course, necessitate the reconstruction of parking lots, buildings, bathing beach and docks at a higher level. The original cost of construction of the lake, including clearing and preparation of the beach, was $140 per acre-foot of storage capacity provided. Now, because of increased costs of construction, the additional storage provided would cost about $300 per acre-foot, including the cost of reconstruction of the various facilities at a higher level.

Desilting Basins. Approximately 50 acre-feet of storage capacity could be provided by two desilting basins, on Mill Creek and Hamer's Creek just above the lake. Construction of these desilting basins would necessitate relocation of a parking lot and several buildings. More than 50 acre-feet of storage would be difficult to obtain without inundating the old mill and village, which have great historic and picturesque value. The cost of providing additional storage capacity in desilting basins would also be around $300 per acre-foot, including relocation of various facilities.

Either raising the dam or providing desilting basins, however, would be in reality only a temporary measure. Since sediment is entering the lake at the rate of 5.25 acre-feet annually, these expedients would provide a "breathing spell" of only 10 to 20 additional years. After that, no further storage could be provided by these means.

Fig. 3 *(Left)* One type of closed sinkhole, which is sealed and ponded, contributing neither water nor sediment to the underground drainage channels • Fig. 4 *(Right)* Another type of closed sinkhole containing colluvial deposits through which water may sink, but not sediment

Plugging the Open Sinkholes. It has been suggested that the open sinkholes could be grouted and sealed, thereby trapping all sediment which reached them and preventing its reaching the lake. There are, however, several drawbacks to this proposal. First, the sinkholes with larger drainage areas will overflow if plugged, resulting in severe erosion and flood damage in surrounding areas. Overflow is actually taking place in many of the naturally closed sinkholes. Secondly, experience has shown that structures for sealing sinkholes usually fail within a few years. It is very difficult to grout effectively all of the limestone cracks around a sinkhole. Some of the structures would have a head of 35 ft of water over them. This would result in water being forced into small cracks in the limestone, slowly enlarging them by solution, and eventually causing the failure of the structures. This method, therefore, does not appear feasible.

Soil Conservation. In relation to the permanency of the protection, the cost of controlling soil erosion on the watershed is by far the most economical method of maintaining the reservoir. As sheet erosion on the 5.29 sq mi of sediment-contributing area is the predominant source of the sediment filling the lake, a complete soil conservation program should be aimed primarily at controlling this source.

Much of the land now being farmed to clean-tilled crops or small grain, or standing idle, is on slopes which are entirely too steep to be cultivated at all. Other land is not so steep, but because of the hummocky nature of the topography it cannot be terraced easily or contour-farmed. Both of these classes of land should be permanently retired from cultivation and seeded down to pasture or planted to trees. Some of the areas with more serious sheet erosion, comprising at least 200 acres, could be bought by the state for this purpose. Grass or trees would, for all practical purposes, halt sheet erosion in these areas.

On the more moderately sloping land, contour cultivation, terraces, diversion ditches, and grass waterways should be used to control sheet erosion. Improved rotations, proper fertilization, liming, reseeding of pastures, and protection of woods from grazing would also contribute considerably to a reduction in sheet erosion.

The gullies in the watershed are not large. Most of them could be stabilized simply by sloping in and seeding to grass or planting to trees. Some small stabilization structures might be required.

A small amount of streambank erosion control work might be necessary on Mosquito Creek, largely in the nature of willow plantings, supplemented by some revetment work. The ditch banks on upper Mosquito Creek should be sloped and seeded to prevent channel erosion. Roadside erosion could be largely prevented by planting of grass, vines, or shrubs.

On the basis of case-history studies in various parts of the country, the author has found[4,5] that such a comprehensive soil conservation program, designed to control all types of erosion, as advocated by the Soil Conservation Service in cooperation with soil conservation districts, will reduce rates of sediment production and reservoir sedimentation by at least 75 per cent.

The cost of such a program, including the purchase by the state of certain areas, would be about $5 per acre of the sediment-contributing area, to the federal government, the state, local interests, and the farmer. This would be equivalent to $3,200 per square mile for installation. It is assumed that once the conservation measures were installed, the farmer would maintain them because of the high benefits to himself. If this installation expense is placed on an annual basis, at 2 per cent interest, it amounts to $64 per square mile annually.

The average annual rate of sediment accumulation in the reservoir is 0.99 acre-foot per square mile of sediment-contributing area. The soil conservation program described could be expected to reduce this rate by 75 per cent, or 0.74 acre-foot per square mile annually, from the time the installation was completed. If an annual expenditure of $64 per square mile would keep 0.74 acre-foot of sediment out of the lake, the cost would be approximately $86 per acre-foot of storage capacity saved. In addition to preventing this loss of storage capacity in the lake, such an expenditure would hold the soil on the farms and reduce the turbidity of the water in the lake, thus improving swimming and fishing.

Fig. 5 An open sinkhole. The surface opening of this sinkhole (not visible) is about 2 ft in diameter

One of the first steps required in order to place such a program in operation would be the organization by the local farmers of a soil conservation district in Lawrence County. Orange County, which contains approximately one-half of the sediment-contributing area, has been organized into a soil conservation district. Lawrence County, however, has not.

RATES OF SEDIMENT PRODUCTION

The second purpose of this study, as mentioned previously, was to obtain information on rates of sediment production which might be expected in the Highland Rim physiographic province.

Assuming a specific weight of the sediment of 67 lb per cu ft, the average annual accumulation per square mile of sediment-contributing area has been 1,440 tons, and per square mile of the entire drainage area, excluding the lake area, 510 tons during the 9.9-yr period of record.

The rate of sediment production, however, has been considerably greater than the rate of sediment accumulation in the reservoir, because some of the sediment has passed over the spillway. A study of the trap efficiency curve developed by Brown[1], and a consideration of other factors, such as the size of the sediment particles and the method of operation of the reservoir, leads to the conclusion that this reservoir has a trap efficiency of approximately 60 per cent. The average capacity-watershed (C/W) ratio during the period of record has been 10 acre-feet per square mile of the entire drainage area and 29 acre-feet per square mile of the sediment-contributing area. If the reservoir has trapped only 60 per cent of the sediment reaching it, then the actual annual sediment load reaching the reservoir during the period of record has been 2,400 tons per square mile of the sediment-contributing area, and 850 tons per square mile of entire drainage area, excluding the lake area.

There are no stream-gaging stations on Mill Creek. However, a study of the records of other gaging stations in this area indicates that average annual runoff during the 9.9-yr period of record was approximately the same as the long-term average annual runoff for this area. It is felt, therefore, that the rates of sediment production derived above may be used as long-term estimates, with no correction for abnormal runoff required.

These values are in close agreement with values computed from the author's previous work (pp. 16-18)[6]. They are also in agreement with the data from the survey of Lake Tandy, Hopkinsville, Kentucky, another lake which lies in the Highland Rim area. This lake's drainage area, with a period of record of 34 years from 1907 to 1941, and a size, exclusive of the lake, of 8.9 sq mi, was found to have an estimated long-term annual rate of sediment production of 830 tons per square mile. The percentage of cultivated land in the watershed was approximately the same as in the Spring Mill Lake watershed.

Using the data from the Spring Mill Lake survey, sup-

ported by other records, the graph shown in Fig. 6 was constructed for estimating rates of sediment production to be expected in the Highland Rim area. In developing the relationship between rate of sediment production and size of drainage area, the same factor was used as was previously developed for the Ohio River and Great Lakes basins.[6]

In this study 41 sediment records from the Ohio River basin, 2 from the Great Lakes basin, and 60 from the Upper Mississippi River basin were used. These sediment records consisted of suspended sediment measurements, reservoir sedimentation surveys, experiment station measurements, and combined reservoir and suspended sediment studies.

The reservoir sedimentation records were corrected, as closely as possible, to include sediment lost over the spillway or through outlets. Suspended sediment records were corrected to include an estimate for bed load. Where older type samplers were used, the results were adjusted to those which would have been obtained with the D-43 sampler. A correction was also made for abnormal runoff during the period of record, assuming that the annual rate of sediment production in this region varies roughly with the square of the annual runoff.

These sediment records were then plotted against size of drainage area, by groups, depending upon the percentage of cultivated land in their drainage areas. It was found that after the variable effect of percentage of cultivated land in the basin had been isolated and eliminated, there was a definite correlation between size of drainage area and rate of sediment production per square mile. In other words, the sediment load per square mile of drainage area was found to decrease with increasing size of drainage area. This general phenomenon is apparently due to a combination of factors, including (1) decreasing stream gradients and consequent lower eroding and carrying capacity, (2) decreasing frequency of basin-wide, high-intensity storms, and (3) evaporation of water, resulting in deposition of sediment in colluvial areas, on floodplains, and in channels.

This relationship, for the Ohio River basin, was found to take the following form:

$$Q = K\,(2.718)^{(-0.367 \log_{10} P)}$$

where Q = sediment load in tons per square mile of drainage area

K = a constant

P = size of drainage area in square miles

The author is greatly indebted to Melvin M. Culp, head, construction and design section, Engineering Division (Region 3), USDA Soil Conservation Service, Milwaukee, Wis., for assistance in developing the relationship. This formula was used in preparing Fig. 6.

In computing the values to be expected with a soil conservation program in effect, a 75 per cent reduction in rates of sediment production was used. Experiment station studies (unpublished) indicate that, where contour farming is substituted for straight-row farming in this region, sheet erosion and sediment production will usually be reduced by 30 to 50 per cent. If terraces are used also, a reduction of 75 to 95 per cent may be expected. If cultivated land is retired to pasture or trees, a reduction of 99 per cent or more is common. Considering the relative areas of land in the Highland Rim province which should have these various types of treatment, a probable reduction in rates of sediment production of 75 per cent, with a complete soil conservation program, which would treat not only sheet erosion but also the other sediment sources, does not appear excessive.

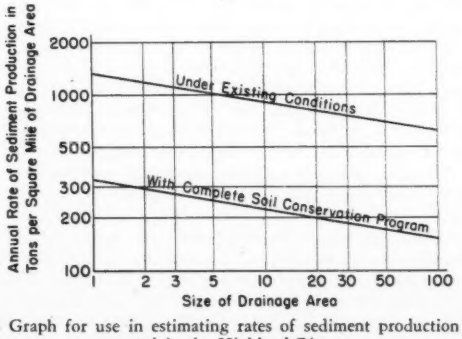

Fig. 6 Graph for use in estimating rates of sediment production to be expected in the Highland Rim area

The assumption must be made, in using this graph, that the topography, soils, degree and length of slopes, land use, and proportionate number of open and closed sinkholes, are approximately the same in other parts of the Highland Rim area as in the Spring Mill Lake and Lake Tandy watersheds. If the land use does, however, vary considerably from conditions in these watersheds (about 60 per cent cultivated and idle), the author's previously developed graph for the Ohio River Basin[6] should also be used in conjunction with Fig. 6. If any of the other factors vary considerably, it will probably be necessary for a sedimentation specialist to make a detailed study of the watershed in question.

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Drying Corn with Forced Air

(Continued from page 72)

Observations have shown that the air distribution is good. It happens, however, that most of the buildings were located in parts of the corn belt where the corn was dry before it was possible to get the buildings erected.

Those farmers who did use their fans, have been well satisfied with the results, and as far as is known, there has been no spoilage.

Farmer Acceptance. Upon questioning purchasers, it was found that they purchased the Quonset 32 corn storage building for these reasons:

1 They needed corn storage and wanted a building of permanent construction.

2 The variety of uses for the Quonset was probably the biggest reason why they bought it. That drying was a necessity for the Quonset corn storage did not seem too important to them. However, all of them seemed to think that forced drying, either with or without heat, was the method of the future.

Although corn drying, both with and without heat, has been given considerable publicity by farm magazines, college extension departments, PMA officials, manufacturers, utilities, and others, only the most progressive farmers are adopting the artificial method of drying corn. Farmers generally are accepting this new idea slowly. However, the farmers who bought the Quonset 32 corn storage this year say they are well pleased with it, and that many of their neighbors are interested in it. Details can and will be improved from time to time, but the fundamental principles of storage on the ground and using artificial drying will remain the main advantages of this new storage unit.

Progress in Chemical Weed Control

By Dale E. Wolf

WEEDS CAUSE an annual loss to North American agriculture of nearly five billion dollars. Some of this loss is caused by weeds competing with crop plants for nutrients and soil moisture, thus reducing yields; by interfering with harvest machinery, sometimes even making harvest impossible; and by reducing the quality of the crop. The realization of this tremendous loss is enough to interest all of us in a satisfactory means of controlling weeds.

Some methods of weed control have been with us since the beginning of agriculture. Man began hoeing and cultivating his crops because he realized that the weeds were competing with his crop. This tillage, alone or in combination with crop rotation, is the oldest method of weed control. It is still a standard and reliable procedure and undoubtedly always will be for most crops.

Biological control of weeds has been used successfully in various parts of the world. The first attempt at biological control of a pest plant was carried out in the Hawaiian Islands by Perkins and Swezy in 1924. Here insects were found which were effective in controlling a thorny shrub, Lantana camara. Probably the outstanding example of biological control of weedy plants is that of the control of prickly pear in Australia.

The chemical control of weeds can be divided into two sections, based on the type of chemical used. These two are non-selective and selective. A non-selective weed killer is one that when applied will kill all the vegetation in that particular area, while a selective weed killer is one that will kill most of the weeds and leave the crop plant uninjured. Both of these types of weed killers are of extreme importance today.

The earliest tests which led to the discovery that certain chemicals were useful as general plant killers and soil sterilants were those of Jones and Orton (1899) and of Stone (1909). These men tested sodium chloride, copper sulfate, several of the arsenicals, and other salts.

Out of these tests it was concluded that the arsenicals were the most satisfactory. Soon sodium arsenite was the standard weed killer of this country and Europe. The largest users of arsenicals as weed killers have been the railroads.

Sodium chlorate, borax, and carbon bisulfide soon appeared as soil sterilants also, and today sodium chlorate is one of the most important non-selective (soil sterilants) weed killers in use. The most extensive use of sodium chlorate has been along railroads in such countries as Germany, Australia, England, and the United States.

Besides this class of non-selective soil sterilants, there is the group of chemicals which will kill nearly all vegetation, but have little effect on sterilizing the soil. This is a comparatively new group of chemicals and no one chemical has been found to be particularly outstanding. Included in this group are ammonium sulfamate (Ammate), several of the thiocyanates, and many of the oil weed killers.

The discovery that certain chemicals possessed selective weed-killing properties was not made until the latter part of the 19th century. Apparently the discovery of selective action of copper salts on broad-leaved weeds in cereal crops resulted accidentally from trials on the control of fungus diseases. Bonnet in France, Schultz in Germany, and Bolley in America found (1896-1897) that solutions of copper salts applied to small grain fields would kill the broad-leaved weeds and harm the cereals little, if any. Soon thereafter successful use of ammonium sulfate, iron sulfate, sulfuric acid, sodium nitrate, and various potassium salts was reported both in Europe and North America.

This paper was presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Guelph, Ontario, Canada, in September, 1948.

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Following this first period (1896-1910) of developments, interest in control of annual weeds lapsed in America. There were several reasons for this declining interest. Among these were the lag in the production of adequate spray machinery, frequent lack of success because of low humidity, and, above all, impossibility of completing a successful spray program during the short time which both weeds and cereals were in the proper state.

Although interest lagged in America, new developments were taking place in Europe. Research workers there discovered that selective sprays such as sulfuric acid not only killed the broad-leaved weeds but also had a fertilizer effect on the cereal crops. Experiments carried out from 1914 to 1922 on small grains in Norway showed an increase in yield on sprayed plots of 25.3 per cent above unsprayed plots.

Meanwhile in the more humid sections of Europe, a combined weed control and fertilization practice was found to be successful. The use of Kainite, a double salt of magnesium sulphate and potassium chloride, with certain impurities, and calcium cyanamide proved most satisfactory of the powdered weed killers tried.

The profitable use of these chemicals depended upon their herbicidal properties and also their value as fertilizer. Therefore, mineral deficiencies of the soil were taken into consideration in their use.

The selective action of all of the chemicals discussed depended chiefly upon morphological differences between crop plants and weeds (amount of leaf surface, pubescence of plant, and position of growing points). With the discovery that certain growth-regulating substances had weed-killing properties a whole new era of chemical weed control was begun. The selective action of these herbicides is apparently related to physiological differences of plant species rather than morphological differences. The most important of this type of weed killers is 2,4-dichlorophenoxyacetic acid, (2,4-D). The discovery of these weed-killing properties of this chemical in 1944 proved to be one of the most important developments in agriculture since the advent of hybrid corn. The use of 2,4-D as a weed killer and the almost unbelievable early results reported stimulated a tremendous new interest in chemical weed control and especially emphasized the need for fundamental research.

After three years of research on the use of 2,4-D as a weed killer, some of the recommendations for its use have been established. There are still many questions, however, that have not been answered, and it behooves all agricultural engineers, botanists, chemists, and agronomists who are working with 2,4-D to concentrate on fundamental problems in an effort to answer some of the many perplexing questions about how 2,4-D works.

With this recent impetus given to weed research, several of the older chemicals have come to the foreground again as herbicides and new compounds have been found useful. Calcium cyanamide has been found particularly useful as has one of its derivatives, potassium cyanate.

More work has also been concentrated on the dinitro compounds and the Stoddard solvents.

Selective chemical weed control today can be, in general, divided into groups depending upon the stage of the crop plant at the time the chemical is applied. These two types of treatment are termed "postemergence" and "pre-emergence."

Postemergence refers to the application of the herbicide after the crop plant is growing, while pre-emergence refers to application after the crop has been seeded but before it emerges. Crops on which postemergence treatments with 2,4-D have proved most successful are corn, oats, barley, wheat, rice, and flax.

It has been estimated that in 1948 nearly 3 million acres of corn were treated in the United States with 2,4-D. This application undoubtedly has reduced the loss normally caused by weeds. In most cases, rates of ¼ to ½ lb of acid equiva-

lent of 2,4-D per acre are used in spraying the cereal crops. Complete cost of such an application would be only about $1.50 per acre. Economically speaking then, 2,4-D has proved itself to be a sound investment in growing weed-free crops.

Onion growers recently received good news concerning their weed problem, which has always been one of hand labor, when spray applications of potassium cyanate were found to kill weeds without injuring the onions. If this chemical proves to be as effective as present reports indicate, its discovery will mean that onion growers will be able to reduce their cost of weeding, and, more important in these times of labor shortage, they will be able to grow comparatively weed-free onions.

The oil products known as Stoddard solvents have been shown to be particularly useful in the selective weeding of carrots. Here again the postemergent application of a herbicide has meant a reduction in the cost of weeding, as before its discovery, carrots were weeded mostly by hand. Stoddard solvent has now been used successfully in carrot weeding for the past four years and it has been fairly well established as a valuable herbicide.

Pre-emergence treatment for weed control was first reported by an Englishman, W. G. Templeman. The value of 2,4-D as a pre-emergence treatment was first demonstrated at the New Jersey Agricultural Experiment Station by J. C. Anderson and D. E. Wolf in 1946. In 2,4-D treatments on field corn, it was shown that under such conditions a crop could be grown to maturity without cultivating for weed control.

Since its original discovery at New Jersey, pre-emergence control of weeds in corn with 2,4-D has been tried throughout North America. Results have sometimes varied, but it is generally concluded by scientists studying this problem that 2,4-D has a definite place as a pre-emergence treatment in corn.

This makes the third year that we have grown corn successfully without cultivation at the New Jersey Agricultural Experiment Station. Yields on the 2,4-D treated, uncultivated plots in last year's tests equalled yields from plots cultivated normally throughout the season. Although this year's tests have not yet been harvested, observations indicate that the yields in cultivated and uncultivated plots will be nearly equal.

Certainly these same results could not be expected on all types of soils, and it will take much more research to determine the value of cultivation, other than weed control on the various soil types. Many factors apparently affect the results obtained from such a treatment. It has been found, for example, that in general 2,4-D pre-emergence is successful on moderately heavy soils while poor weed control and crop injury is obtained on light soils. Rainfall and soil temperature may also affect this treatment. This is one of the outstanding examples of a very real need for fundamental weed control research.

PRE-EMERGENCE WEED CONTROL FOR CORN

This type of weed control has tremendous meaning for the corn grower. Cultivation is not only an expense but also comes at a season when our farmers are already short of labor for hay harvesting. The elimination of the necessity for one or two cultivations or all cultivation in corn would greatly help the farmer in arranging his work and would reduce the cost of growing corn.

Elimination of all cultivation would make it possible to plant more corn per acre and thus raise the productivity of the land. These possibilities may seem far removed from present practices of corn growing and probably are hard to visualize clearly, yet they are possibilities.

Experiments on the use of 2,4-D as a pre-emergence treatment for crops such as asparagus, lima beans, and cotton are now being conducted throughout North America, but all of these are still very much in the experimental stage.

The use of calcium cyanamide as a pre-emergence treatment to control weeds in corn is also creating considerable interest today. Experiments at the New Jersey Agricultural Experiment Station in 1947 indicated that 300 lb of granular calcium cyanamide per acre applied just after the corn was planted eliminated the need for the first two cultivations. Yields from these plots were double those of plots cultivated normally, the treated plot yielding 77.9 bu per acre and the cultivated plot yielding 37.1 bu per acre. This experiment was conducted on a sandy soil. Early observations of a test on the same soil type in 1948 indicate that yield differences will again be significant.

Besides these two chemicals, several of the contact weed killers previously discussed are now being tested to determine their value as pre-emergence treatments. These may prove highly satisfactory.

The future for chemical weed control looks bright. Each year there will probably be new herbicides discovered that will have a specific use. Several of the newer chemicals being tested today are sodium isopropyl xanthate (N.I.X) which has been found useful in the selective weeding of lima beans; pentachlorophenate used as pre-emergence treatment of pineapples; trichloroacetate, used against Johnson grass; and phenyl mercury compounds which have been used successfully as selective crabgrass killers. Aside from these, many new chemicals are now being tested in laboratories all over the world.

The chemical weed control field has hopefully looked toward agricultural engineers for methods of applying these various herbicides. Probably the most important development in this field has been low volume application. When 2,4-D was first used, the most common type sprayers were the orchard or potato sprayers which applied from 100 to 200 gal of solution per acre.

UNIFORM COVERAGE OF SPRAY MOST IMPORTANT

It was discovered in 1947 that in most instances the amount of water per acre was unimportant in spraying 2,4-D so long as uniform coverage was obtained. At this time operators began spraying 5 gal per acre instead of 100 to 200 gal. This was the boost chemical weed control needed to expand throughout the more arid regions of the country. Low-volume spraying meant that the application would require less labor in refilling spray tanks and much less time.

Today nearly the whole 2,4-D spray field has adopted this low-volume method made possible by specially designed nozzles and pumps. High volume (50 to 200 gal per acre) is still used with most of the other weed killing chemicals and thus there is still a need for this type of sprayer.

Regular gravity-feed spreaders have proved satisfactory for applying granular cyanamid. This material has also been applied successfully by the use of the newer lime and fertilizer spreaders. The most important requirements are a method of rate regulation and a means of uniformly distributing the material.

The field of chemical weed control still needs much help from agricultural engineers. Much more research on types of pumps for the various herbicides is needed. Constant pressure is essential if uniform coverage is to be obtained, and there is room for improvement along this line in sprayers. Too many of the sprayers we have now do not maintain a constant pressure and this might explain some of the erratic results obtained where 2,4-D has been used.

Research with spray nozzles has kept up with the weed control field to date, but there is a definite need for the development of nozzles to be used for specific herbicides and for particular type of spraying. A good example of the latter is the need for nozzles adapted to roadside spraying. Nozzle research should be particularly concerned with accuracy of coverage.

Present-day sprayers are in general more expensive than the average small farmer can afford. Particularly in line with the eventual decline in the prices of farm commodities, agricultural engineers ought to strive for a less expensive weed sprayer.

Let me assure you that those of us in the general field of weed control invite the agriculture engineer to continue to increase his research on weed control equipment. As is true of the physiological phase of weed control, fundamental research in agricultural engineering will aid in answering many of the new existing questions on what herbicides will and will not do.

In order to coordinate information on weed control research, a number of conferences have been organized in the United States and Canada. In the *(Continued on page 80)*

Runoff Losses from Permanent Pastures and Woodlots

By R. B. Hickok

MEMBER A.S.A.E.

PERMANENT pasture and woodlot covers provide excellent protection of soil from erosion, and also reduce the frequency of high rates of runoff resulting from flash summer rainfalls. However, these types of cover may not reduce the total seasonal runoff water losses. This is shown by results of experiments being jointly conducted by the research branch of the Soil Conservation Service, USDA, and the Purdue University Agricultural Experiment Station near Lafayette.

Runoff measurements have been made from several small agricultural watersheds (2 to 4 acres)since 1940. It has been noted that in any period of heavy, protracted rainfall, as frequently occurs in the spring and occasionally in the fall of the year, the soil in the woodlot watersheds has reached a saturation point, after which a very high percentage of the subsequent rainfall ran off. To a lesser extent this has also occurred with the permanent pasture watersheds and even those under established meadow. This runoff is contributed to very substantially, and extended in duration, by water moving laterally out of the upper soil strata.

The effects of this on the total annual runoff losses is well exemplified by the data collected in this experiment during the past year. The total rainfall and its seasonal distribution in 1947 were very near the average of the U.S. Weather Bureau records for the Lafayette vicinity. There was probably somewhat more than the normal number of storms and total amount of rain falling at "excessive" rates. However, there was no instance of rainfall intensity exceeding the annual expectancy.

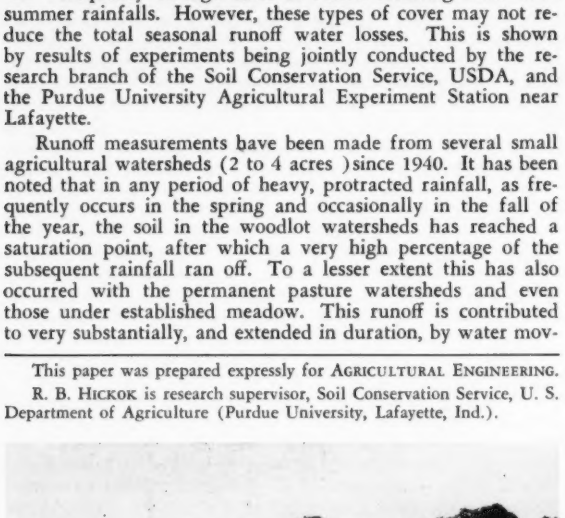
The average annual runoff in 1947 from six rotation-cropped watersheds, two each in corn, wheat, and soybeans, under a prevailing type farming on moderately well drained, prairie soils was practically 6 per cent of the total rainfall and snow, and a little under 2 per cent from a similar series of cropped watersheds under a conservation treatment. Compared with these losses from cropped watersheds, the average annual runoff from two well-managed permanent-pasture watersheds on the same farm was slightly over 6 per cent.

Another pair of well-established and moderately grazed permanent-pasture watersheds on another farm with slower draining upland soils lost an average of approximately 12 per cent of the total rainfall. There are two woodlot watersheds immediately adjacent to those in permanent pasture on this farm. One, which has been open to livestock for a number of years, lost over 14 per cent of the annual rainfall in runoff. The other, which has been protected from livestock since 1939 and has substantially more leaf litter and undergrowth, lost almost 24 per cent of the rainfall.

There have been very few critical runoff rates from the wooded and grassland watersheds which would contribute importantly to upstream, "flash" floods. However, there have been many periods of sustained runoff at moderate rates from these watersheds aggregating relatively large amounts which would contribute to downstream floods on major streams, occurring as a result of protracted rainy periods of several days over wide areas.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

R. B. HICKOK is research supervisor, Soil Conservation Service, U. S. Department of Agriculture (Purdue University, Lafayette, Ind.).

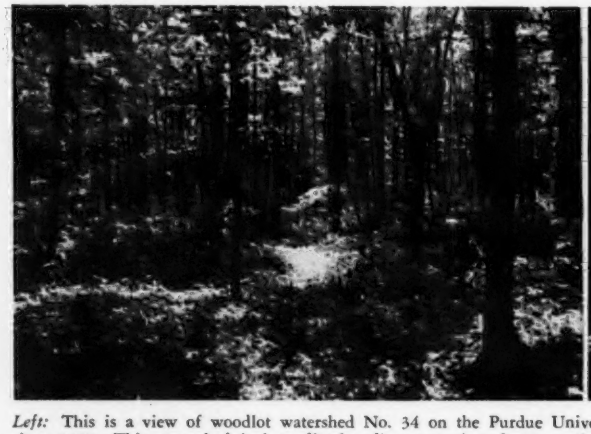


This upstream view of a runoff measuring installation (Type H flume and water-level recorder), with recording rain gage near by, is on permanent pasture watershed No. 32 on the Purdue University dairy experimental farm near Lafayette, Ind.

Chemical Weed Control

(Continued from page 79)

United States we have a Western, a North Central, a Northeastern, and more recently organized a Southern Weed Control Conference; and in Canada there is a Western Weed Control Conference. Annual meetings are held by these groups and there all phases of weed control are discussed.



Left: This is a view of woodlot watershed No. 34 on the Purdue University dairy experimental farm, which has been *protected* from grazing since 1939. This watershed is immediately adjacent to that shown at the right. • *Right:* This view is of a portion of woodlot watershed No. 33 which has been *unprotected* from grazing. Prior to 1939 both the woodlot watersheds shown in these two views were open to grazing for a number of years and were at that time in a similar condition

Some Tile Drainage Experiences

By John R. Haswell

FELLOW A.S.A.E.

THE PRESENT wave of interest in tile drainage is similar to that which developed during and after World War I. The shortage of farm labor forced the use of all possible labor-saving equipment, which could not travel through bog holes. A desire to increase food production called for the drainage of many wet spots in good fields. Most of the areas had been in production with horses, but tractors could not do a satisfactory job. Besides, there is always a desire for uniform fields which can be planted or harvested all at one time. Inequalities in drainage prevent this or make it impossible to cultivate the wettest areas.

Fig. 1 This picture shows the use of the sight bar on a Buckeye traction ditcher, which is sighted on two or more targets to get accurate grade. One of the targets is shown in the right foreground

Much of the farm land in Pennsylvania has been drained by open ditches, pole or stone drains. A few persons can remember the immigrant ditchers who dug for 30 cents per day and their board. Some of their old drains still operate, particularly when a new line of tile provides a better outlet. The same can be said for the little horseshoe tile and the 1½-in diameter tile with collars. Much tile was laid 18 in deep or less, and plowing in dead furrows often hit them. Quite often a farmer on land new to him will say, "I don't know where the tile is; I haven't plowed this field yet."

Previous to the formation of the Pennsylvania Agricultural Extension Service, there has been employed a drainage engineer who did very careful work but used 3-in tile for his laterals and seldom anything larger than 4-in for the main.

After the establishment of our state extension service several college graduates in agriculture spent part time in taking levels for drains, and some of the teaching staff would assist with tile layout and construction. I was appointed the first full-time agricultural engineer in the extension service after having been with the U. S. Department of Agriculture for ten years. It was thought at the time that there might be a possible chance of doing some ditching with traction machines similar to what New York had done during World War I. This was investigated as a part of a study of community tile drainage construction.[1]* The experience of working the 13 state-owned ditchers in New York provide information of considerable use to purchasers at the present time, when the differences in the present economic situation are considered. One of the machines used in the study was owned by a group of 20 persons in Pennsylvania. It failed to give satisfaction due to poor operation and management. Until recently the only other tile ditcher in the state was privately owned and would not do any custom work. A few city contractors could be gotten at a high figure, but they would not finish the ditch bottom in a satisfactory manner to receive the tile without considerable hand labor.

There has always been a large interest in drainage which is attested by the production of the Larimer ditching plow in the western part of the state and the Umstead ditcher by several brothers in the central part. The latter machine had a cutter with an elevator which discharged the earth to one side. It was horsedrawn and could go to a depth of 54 in. It is illustrated as Fig. 5 in the May, 1920, issue of USDA Farmers' Bulletin 1131, "Tile Trenching Machinery." The one left in the state when the brothers moved to Ohio went into the scrap drive for World War II.

Due to the depression after World War I, few farmers were financially able to construct any great amount of drainage, but the work always attracted considerable interest. Considerable tile was installed with rooter plows from highway crews; at least five Jeschke machines were bought and worn out and a variety of other scrapers were employed. None of these could get to a satisfactory depth with one cut.

This paper was presented at the Winter Meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division.

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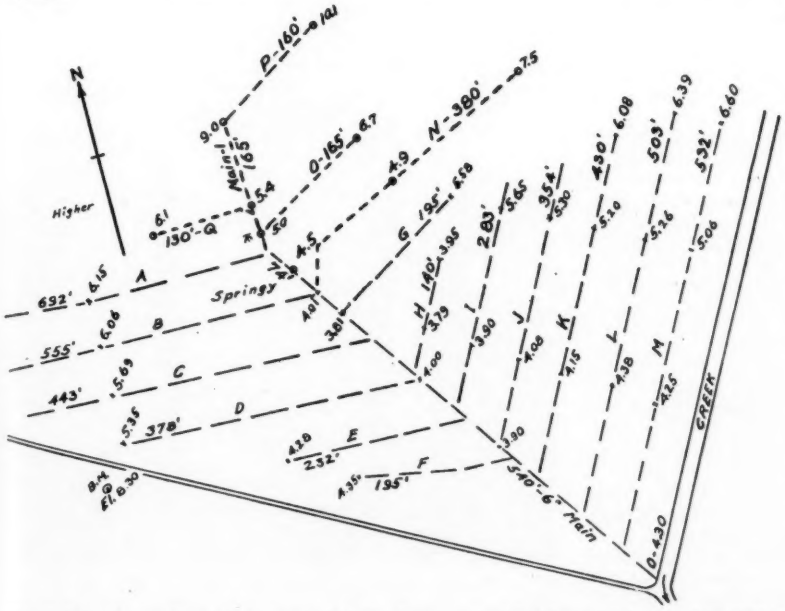


Fig. 2 Part of map from stadia survey for tile drainage on rich tobacco land. The first 5000 ft are shown by long lines. Lines A and G (4-in tile) did not catch seepage from strips on higher land so 1000 ft (short dashes) were added the next year. For clarity some elevations and distances are omitted

* Superscript numbers refer to appended references.

Fig. 3 This picture shows about as dry a dynamite ditch as would propagate. Fresh dynamite is necessary. An hour's loading, 200 ft, serves as a demonstration

The general situation was reported at the 1940 annual meeting of the American Society of Agricultural Engineers[2]. Few of the soils in the state, which we have drained, respond readily to tile placed much over 30 in deep, and we always insist on 24 in of earth cover over the tile. Therefore, unless the soil is particularly open, or unless it is necessary to go deeper to get a minimum fall of 0.2 ft per hundred, we usually stick to the 30-in minimum depth. In the areas requiring a uniformly spaced lateral system, a distance of 75 ft between laterals has usually given adequate drainage for grain crops. Where the land is more valuable and crops such as potatoes or tobacco are grown, we have constructed systems of 35 and 60-ft spacings (Fig. 2).

It has sometimes been difficult to get farmers to install tile in a ditch on a rather flat grade amply sufficient for an underdrain, but where the free water does not flow readily on the bottom before the tile is laid. Tile requires only from one-third to one-half the fall of a small open ditch, even where the water moves smoothly on the earth bottom. The difference spells success or failure in some systems where the outlet is fixed and enough depth of drain for satisfactory operation is hard to get. Some county agricultural agents can set grade bars from the survey stakes and thus insure careful work. On the other hand, after the county agents and specialists have become established in a neighborhood, the farmers will quite often say one to another, "Do it the way they tell you, whether you think it is right or not."

In the spring of 1944, R. J. McCall was called upon to look at some wet land which I had examined 15 years previously and at the time suggested that tile was needed. McCall urged the installation of tile, and conditions were very similar to what they had been in World War I. The winter had been a very wet one, but the county agent in Venango County was able to get three farmers to do their work in sequence and order 10,000 ft of tile. On June 6, a small ditching machine was trucked in and did the work in about one week of operating time, including moving from farm to farm. The first place the machine worked was the one which had been hanging fire for 15 years. A motion picture was taken of the work and served as the main part of a film on better farm drainage. One of the farmer's sons, the county agent, and several others learned to operate the ditching machine. Much more work would have been done if drain tile had been available.

The work spread west from this county to one with flatter land, where a farmer got a priority for a ditching machine. He found a man interested in doing custom work and turned it over to him. A Model 1 Buckeye machine was purchased, and it was the last one available for the duration of the war. All of the later ones purchased have been Model 301 of 7½ tons, or three tons less than the first.

Progress in this work is shown by the following tabulation taken from the combined county agents' reports for the entire state as made to Washington:

NUMBER OF FARMERS ASSISTED WITH DRAINAGE

Year	1943	1944	1945	1946	1947
Counties reporting	51	56	51	60	62
Farmers assisted	458	627	898	2648	3019

Our state reports go into a bit more detail and for 1947 list 397 demonstrations of both tile drainage and dynamite ditching and 56 field meetings at demonstrations with an attendance of 2913. There were 20 winter meetings with 992 farmers attending and 2723 cases of individual assistance. For 1948 there were 608 demonstrations, 128 field meetings with 3065 out, 32 general meetings with 1418 attending, and 3764 cases of individual help. This is a lot of work for a four-man department which covers practically all other agricultural engineering subjects, and represents only 36 per cent of the year's total. It would have been impossible to carry through without the help of an active group of county agents.

The year 1948 started with nine ditching machines in the state. By midsummer there were 15 machines working, now there are 22 machines owned in the state. They are about equally divided in ownership between farmers who first wanted to drain their own properties and then do custom work and men with a farm background who wanted the farmers' business of ditching. Some of the latter are war veterans. It is a pleasure to help them get started in a business which holds their interest and which has made them enough to pay for their equipment, besides providing a living. Four of the purchasers of the machines, each of which cost about $8,000, have each bought a second one in order to take care of the jobs needing to be done. It seems a fitting climax to over a quarter of a century of work where hand labor, horse and tractor-drawn plows and scrapers, and ill-adapted trenchers were tried and found wanting.

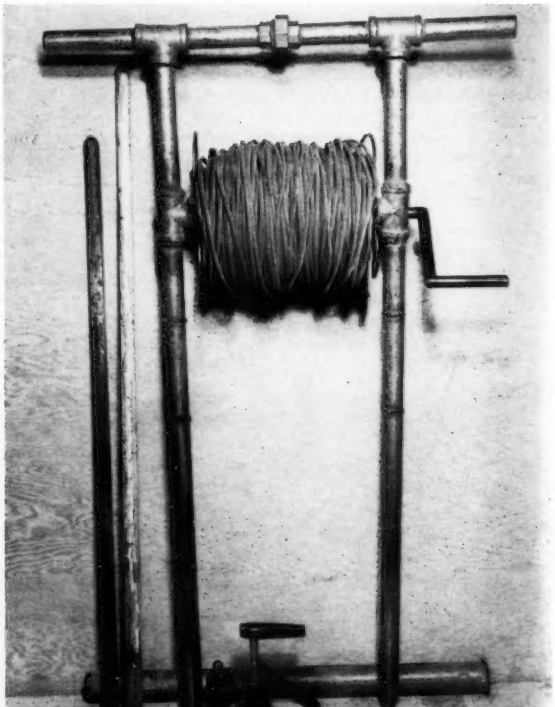


Fig. 4 Tools for dynamite ditching. The two T punch bars are connected by a union to form a frame for the wire reel with 425 ft of duplex lead wire. The slotted crank slips into the hollow shaft through a hole in the T. Sleeve for quicksand is shown in background, with 10-cap twist machine and steel point in front. Welding rod beads at 18 and 24-in depths on T bars

Fig. 5 Outlet improvement. The state highway department enlarged and lowered the culvert to provide better drainage

Besides the 22 machines mentioned above there are at least ten others, such as backhoes, power scrapers, and sewer excavators owned by contractors not especially interested in farm work but who occasionally do some farm drainage.

One machine made a record of 3600 ft of ditch 30 in deep or over in one day. A good day's work is 2000 ft. With moving between jobs, lubrication, adjustments, etc., the operating time is greatly reduced. They ordinarily dig 7 ft per min. Quite a few of the machine owners supply the tile as some tile manufacturers will not sell direct to farmers. A small tractor with a bulldozer blade is often provided for backfilling when the farmer has none. The price for digging, supplying the tile, and backfilling is around 18c per ft for 4-in tile, the smallest we use. The farmer has to distribute the tile about the farm and lay it. This avoids any argument about bad joints which cause trouble from poor laying.

Most of the operators have some form of surveyor's level with which to check the fall in the ditch. They set several targets along the proposed line with crossarms at a given distance above the bottom of the ditch. With the sight arm on the machine set at the same given distance, there is no chance for a careful operator to provide a poor grade in the ditch. Such accuracy (it can be within 0.02 ft) is not possible with other types of diggers. We urge that the tile be laid in the shield directly back of the machine as fast as it digs.

The operators have been very willing to cooperate and take suggestions willingly, particularly as to intercepting drains. We class many of them as local leaders. They take pride in their work. Most farmers will install tile as our experience dictates, but a few of the "old timers" want to put it where the water shows on the surface. On hillside seepage it is necessary to cut off the water at least at the 30-in depth, which usually puts the tile a rod above where the water shows. The following quotations from two typical weekly reports in early August from one county agent illustrates the point:

"Approximately 24 miles of tile drainage have been installed on 36 farms. Eight additional layouts were made this week. One machine started operation on March 22 and the second on June 29. Field demonstrations and individual farm layouts have been used to show the importance of intercepting drains to prevent seepage on the hillsides. . . . . "

"Field demonstrations were held this week when the traction ditchers were in operation. These were both excellent examples of how to locate tile to intercept seepage on slopes. One of the men said, 'I can see where I have wasted a good many weeks work and a lot of tile by not understanding how to tap the water-bearing strata.' Layouts have been made on 11 additional farms this week."

Equally interesting reports are available from most of the state, as all but one of the 67 counties reported some drainage work.

The enormous amount of strip cropping which has been laid out and installed has held the water on hillsides to such an extent, in many cases, that supplementary tile drainage has been required. Practically all the counties are having this result, and the tile provides a channel which will not wash. Strips or diversion ditches through hillside springy spots in most places only spread the nuisance to a larger area. On submarginal farms, with the poorer class of farmers, open ditches may be of some cheap help, but the real farmer wants a clean field.

Dynamite ditching still continues to be the ideal way to provide outlets for tile where streams need deepening. Open ditches were also used in meadows kept for pasture, though in this case the cattle rapidly tramp them shut. Some tile was installed in pastures where a few years ago the farmer would have been satisfied with open ditches.

The dynamite ditch blast (Fig. 3) shows the results of blowing where there was very little water. A satisfactory ditch resulted but if the dynamite had not been so fresh and the weather warm, it is doubtful if the blast could be made to propagate. The length is about 200 ft, which ordinarily requires one hour of preparation. It is hard to get farmers to wait any longer to observe the shot.

The equipment used for setting the dynamite and detonating it is shown in Fig. 4. A solid steel point is turned from a shaft and set at the tip of 1 in galvanized water pipe. The T's used to hold the reel as a windlass are not only threaded but also welded to keep them from unscrewing and to provide extra strength. Beads of welding rod are applied at the 18 and 24-in depths. The two punch bars can be separated by the union at the top and provide a very handy piece of equipment for any drainage specialist or county agent. The windlass was developed by V. S. Peterson while a member of our extension staff. Broomsticks make the best loaders. The little 10-cap twist machine at the bottom of Fig. 4 is ample for the minimum of 425 ft of lead wire which we use. It also has power enough to explode several extra caps which might be required around any stumps or stones encountered. The larger pipe in the background serves as a sleeve over the regular T bar in quicksand. Dynamite can be pushed through it to the bottom of the hole and held with the broomstick while the sleeve is being withdrawn. A hole is drilled in the pipe T to permit the crank to go down the reel shaft and engage the rivet.

While we have in some instances installed tile under deadfurrows on flat areas which have been plowed in lands[3], our farmers would rather put in a little more tile.

Our drainage work is often limited by the depth of highway culverts. An example of cooperation between the farmer and the highway district engineer is shown in Fig. 5. Here an 18 in culvert was too shallow for at least 12 acres of excellent muck ground. Inasmuch as the highway was tar macadam and the headwalls loose stone it was a relatively simple matter to get 4 ft more depth and install the larger culvert. This, however, was only possible because there was ample fall down to a lake in the background and only a short length of outlet ditch had to be deepened.

We recommended to the Governor's postwar construction program that all road culverts or bridges be so built that there could be a depth of drainage in the adjoining cropland of 3 ft with a minimum fall of 0.2 ft per hundred to the culvert. In some places this may require a pipe lower than the culvert supplied for surface water, but if such a pipe is installed, the future improvement of the land adjacent to the highway will not be jeopardized.

This paper has dealt primarily with extension work in drainage. Those who wish a general discussion of the whole subject, will find it covered in many state extension bulletins particularly adapted to the areas served. The one for Pennsylvania is entitled "Drain the Wet Spots."[4] "Drainage in the Humid Regions"[5] is a brief discussion of the subject from my own observations. The USDA 1938 Yearbook, "Soils and Men," contains a bibliography which many may find of interest. A later reference is "Modern Soil Science"[6] by Dr. Charles E. Kellogg. The article contains a warning to all who would spend money for tile; it is this: "Water control without proper soil fertility may be impractical and wasteful." Dr. Kellogg brings out the point that slow erosion may improve the soil on gently rolling relief, *(Continued on page 85)*

Irrigation by Water Spreading

By Clarence F. Vogel
ASSOCIATE A.S.A.E.

MANY FARMERS have areas suitable for a water-spreading irrigation system. Wherever there is a combination of a watershed with considerable runoff and a lower flat area of about 1 per cent slope, such a system may be possible. The area to be irrigated might be small — from an acre on up — depending on the situation.

The particular system to be described in this paper has about 40 acres that will benefit from the runoff water from a 500 to 600-acre watershed. Twenty-three acres can be flooded; the other 17 acres is affected through the additional subsurface moisture. All the dikes were constructed with ordinary farm wheel-type tractors, moldboard plows and one-way disks.

The USDA Soil Conservation Service did all the engineering, starting with a preliminary survey and through all the mapping, laying out, and checking of the system as it was constructed.

First a diversion dam was built with outlet ditch leading to the area to be irrigated. A gate was placed in this ditch to control the water if desired.

The spreader irrigation dikes, as well as the trail dikes, were constructed with a broad base and flat water-channel bottom. This required considerable earth moving. The trail dikes were constructed with the same slopes on each side, while the spreader dikes were made with the greatest slope on the lower side and a flat slope on the upper side. All the dikes were built with gently sloping sides to permit haying or cropping operations over them. With all the land in production, weeds usually found in ditches and dikes can be eliminated.

In building the spreader dike, more dirt was moved from the lower side than from the upper, or just the opposite procedure as used in terrace building. The resulting water channel is shallow, which is much better for alfalfa.

The spreader dikes were flat the entire length of each dike. The only provision for drainage was the outlets on the opposite end of the dike from where water entered from the upper dike or from the diversion dam outlet. The size of the outlets were made to match the amount of the water entering the system from the diversion dam. When the system is in operation, only the top of the dikes protrude above the water; yet, since the water is shallow, it quickly soaks in or drains away when the water stops entering the system.

This type of irrigation system has the greatest possibilities in areas of low average rainfall where "flash" floods or flood rains are likely to occur in late spring or early summer. Some moisture can also be retained from winter runoff.

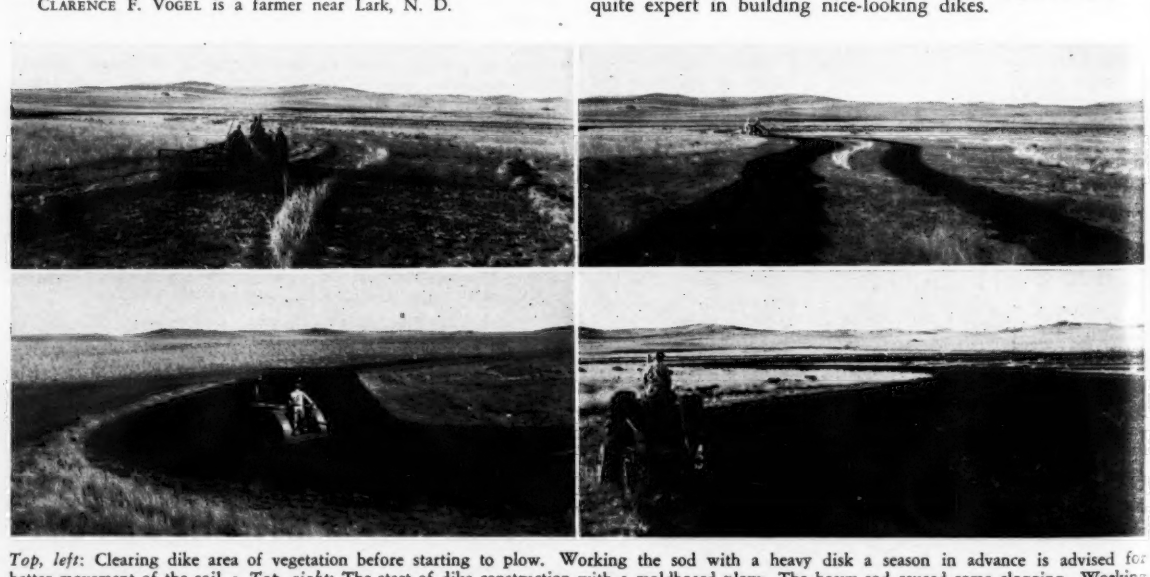
The dikes were built in the slack season of the fall, just before winter set in. The field was an old alfalfa field with about 10 to 12 in of growth still standing. This growth was removed by mowing and sideraking the hay out of the way. The first dike was constructed without removing the growth. There was considerable clogging of the plows as the earth was moved into the center or top of the dike. It would be most desirable to build dikes on a field free of vegetation, such as a summer-fallow field.

The dikes were built on much the same plan as terrace building with a plow. The first furrows were plowed about 5 ft on each side of the stake line. Twelve furrows were made on the lower side, and twenty-four furrows on the upper side. A four-bottom, 14-in plow was used for most of the construction. Coulters were removed to give the trash more space to get through. The lower side of the dike received two complete plowings to one plowing on the upper side. The resulting dike (on 1 per cent slope) was almost flat on the upper side, and steeper on the lower side. The dike shapes up very nicely as the plowing continues to the desired dike height. The SCS engineers recommended an 18-in dike to give a 6-in freeboard to prevent the water from spilling over the top of the dikes. The dikes were built to a loose height of 24 in to obtain a settled height of 18 in.

Neighbors helped in building the dikes by bringing their tractors and plows. We found the two-bottom plows worked best. There was more packing from the extra tractor trips and less clogging by the alfalfa crowns. All the neighbors became quite expert in building nice-looking dikes.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Portland, Ore., June, 1948, as a contribution of the Soil and Water Division.

CLARENCE F. VOGEL is a farmer near Lark, N. D.



Top, left: Clearing dike area of vegetation before starting to plow. Working the sod with a heavy disk a season in advance is advised for better movement of the soil • *Top, right*: The start of dike construction with a moldboard plow. The heavy sod caused some clogging. Working the sod first with a heavy disk is recommended • *Bottom, left*: The dike about one-half completed. Uphill side is at the left • *Bottom, right*: A completed plow-built dike. The plowing outfit is moving soil toward the base of the dike to reduce water depth

The one-way disk pulled at fast tractor speeds is an excellent earth-moving machine. The one-way should have large disks, well scoured, wide spacing, and equipped with trash guards or scrapers to keep the loose damp earth from building up between the disks. We were unable to use our own one-way disk after loose dirt had started to accumulate because of its close spacing and lack of trash guards. It worked fine, however, on the final smoothing operation and will be an excellent machine for maintenance of the dikes. Disks do their best work in light dry soils.

The moldboard plow works well as an earth mover in the widest variety of conditions. While the two and three-bottom plows worked better than the four-bottom plow under severe trash conditions, the four-bottom plow and the large tractor were easiest to handle, and did by far the fastest job of moving dirt. The moldboard plow works best when soil is wet enough to keep the plow scouring. Building dikes on ground kept clean of vegetation two to six months before building the dikes would help considerably for proper moisture condition and freedom from trash.

This spreader irrigation stopped all the run-off from small showers or thawing of snow in winter. Sufficient water ran off the watershed area to fill and overflow the dike area three times in the past year. The control gate was closed to keep water from running on the field when not wanted. Two of the floodings were in late winter and early spring. The last one was about July 15. Very little extra moisture was needed during June when the rainfall is normally the highest. This ground did not seem to be dry at any time during the growing season.

It will be difficult to estimate how much more hay will be grown because of irrigation. It appears that the yield may run from two to three times the former yearly tonnage per acre.

Spreader irrigation systems have a place where moisture is inadequate during the growing season. When the farmer can build his own system, he will also be able to maintain it. The use of the wide-base flat-type dikes requires more earth-moving, but there is less damage to crops since the water is shallow. There is less damage by erosion and bad weed conditions. Little cash outlay is necessary, since the ordinary farm machines are used.

Farm income can be surer from the higher yields, either in crops or more adequate feed supply for livestock.

Tile Drainage Experiences

(Continued from page 83)

while the same type of soil on flat land would develop a claypan. It is these claypans which tax the ingenuity of the drainage engineer.

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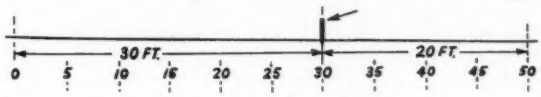
HOW TO BUILD A WATER-SPREADING DIKE WITH MOLDBOARD AND DISK PLOWS

The ideal dike, with 1 per cent maximum slope, is adapted to cropping and farm machinery operation. (Arrow indicates dike height of 18 in)



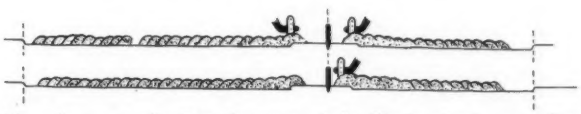
Earth moved in from a 50-ft width builds a tillable dike readily crossed by farm machines. (Arrow indicates dike center)

Clear away vegetation before starting to plow

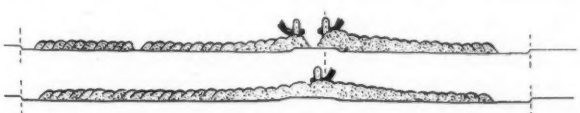
Skim off the alfalfa crowns and grass sod in the first operation

Backfurrow two waves or strips of soil toward the stake line

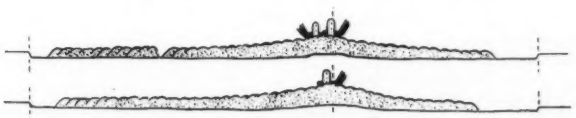
Make the upper wave of soil wider than the lower wave. (Arrow indicates front furrow wheel of the plow)



Move the waves of soil to the center of the dike by plowing as indicated



The waves of soil meet at the center of the dike

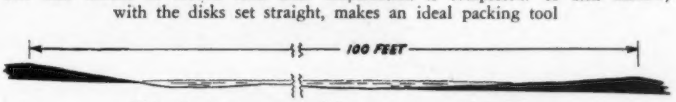


Continue backfurrowing to the ridge to obtain the desired height

This shows the shape of a well-constructed, plow-built dike before settling

Fill in the channels (indicated by the arrows) by backfurrowing toward the base of the dike

The dike should be seeded soon after construction is completed. A disk harrow, with the disks set straight, makes an ideal packing tool



This shows water spread between two settled dikes

Sprinkler or Other Methods of Irrigation

By M. R. Lewis
MEMBER A.S.A.E.

THE subject, "Sprinkler or Other Methods of Irrigation," implies comparison of the advantages and disadvantages of the use of sprinklers as compared with those of other, that is surface, methods of irrigation. Probably that comparison is of primary interest to the dealer in sprinkler equipment and to most irrigators. It is important on all areas where conditions will permit surface irrigation with some but not too great difficulty.

There is another field, however, which appeals to me as being of very great importance; so, before starting on a recital of comparisons, let us examine this use of sprinklers. It lies in those areas where sprinkler irrigation can be used but where surface methods just won't work. That, to my mind, is the greatest advantage of the sprinkler method.

The problems of such areas explain the interest of the Bureau of Reclamation in sprinkler irrigation. Some time ago it became evident that certain proposed projects were not feasible if the distribution of water to the fields depended on surface methods. Because of other desirable features on these projects, the Bureau became interested in the possibility that the application of sprinklers might make irrigation feasible.

Non-irrigability under surface methods may be due to the extreme permeability of sandy soil, which results in waste of water by surface methods. It may be due to extremely steep slopes where erosion by water applied to the surface of steep slopes cannot be controlled. Or it may be due to other topographical characteristics of land.

In the Northern Great Plains there are large areas of glacial soils with "pothole" topography. It would be almost impossible to distribute water by open ditches to farms and fields in such areas. The results of surface irrigation, moreover, might be unsatisfactory.

Another example of a project which had been considered as infeasible when surface methods of irrigation were to be used is the proposed project at The Dalles, Oregon. On this project the slopes are very steep and the soil is easily eroded. The Bureau of Reclamation has recently completed a report on this project which proposes that water be distributed to each farm unit in a closed pipe under pressure. Each farmer will then have his own sprinkler system but will need no pump or motor.

In areas of this sort which cannot be successfully irrigated by surface methods, the question is not how much more or less sprinkling costs but simply whether the expected returns will justify the costs of irrigation including those for sprinkling. Any comparison with surface methods is not pertinent to the problem.

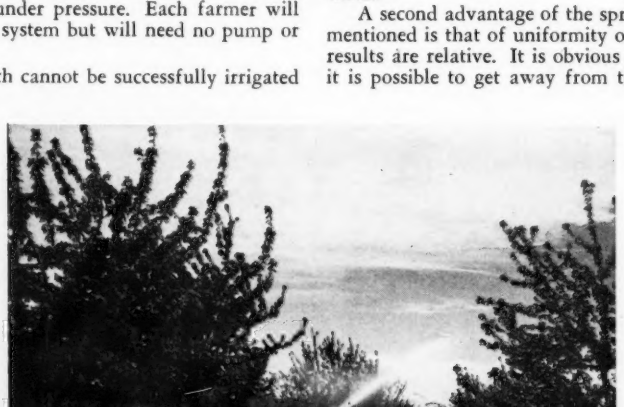
In areas where there is a choice between sprinkling and surface methods, the matter of relative advantages and disadvantages becomes important. Probably the most talked of advantage of sprinkling is that of saving water. There is no doubt that in many cases a material saving can be made. These are shown by many records. Careful study, however, will show that most of these represent instances where the quantity of water used by surface methods was excessive.

In a recent case a great saving in water was shown by the use of sprinklers on the Yuma-Mesa Division of the Gila Project in Arizona. Mr. Wolfe, a potato grower, leased 120 acres from the Bureau last fall. He grew a crop of winter potatoes under sprinkler irrigation. His actual use on the crop was 9 in of water. This was applied in approximately half-inch applications at weekly intervals. To have made the same number of applications by surface methods would have required several feet of water. The same grower has recently harvested another crop on the same area, but we do not have a record of the water used.

Here in the Pacific Northwest, another series of records is available. Cecil Clark, a well-known orchardist of the Yakima Valley in Washington, made a survey of the use of sprinklers by fruit growers in that state. To his question as to water consumption, 130 out of 152 fruit growers reported an average saving of 24 per cent as compared with their former use by surface methods.

It is obvious that any saving of water by sprinkling as compared with surface methods is a function of the loss by both methods. Under the best conditions excessive losses by surface runoff and deep percolation can be entirely eliminated where surface methods of irrigation are used. In such instances there can be no comparative saving by sprinklers. Allan W. McCulloch* has given rules for estimating the field irrigation efficiency under sprinkler. Mr. McCulloch's rules indicate that losses by sprinklers will run from 20 to 50 per cent and possibly more. These losses are as great as the corresponding losses with surface irrigation under good conditions. It, therefore, appears that no general conclusion can be drawn that sprinkler irrigation will always save material quantities of water.

A second advantage of the sprinkler method which is often mentioned is that of uniformity of application. Here again the results are relative. It is obvious that by the use of sprinklers it is possible to get away from the dry zones which occur in the center of the space between furrows or corrugations and that no dry border dykes are required. It is also obvious that with sprinklers the danger of excess percolation at the upper end of irrigation runs is avoided. On the other hand, it has been found very difficult to secure really uniform application of water by sprinklers. The manufacturers of the equipment are continuously working on this problem and with careful design and operation, reasonably good results can be secured. One difficulty which has not yet been overcome is the dislocation of the pattern caused by high wind movement.



This picture shows sprinkler irrigation of a cherry orchard at The Dalles, Ore. Note the sharply rolling topography and heavy cover crop. Photo by S. Rasmussen, U. S. Bureau of Reclamation

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Portland, Ore., June, 1948, as a contribution of the Soil and Water and Rural Electric Divisions.

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*Personal letter dated March 1, 1948.

Sprinkler irrigation has been found to be advantageous on sloping grounds where it is difficult to prevent erosion in furrows or corrugations. It is obvious that prevention of erosion by the use of sprinklers depends on using an application rate so low that no runoff occurs. It is believed that the use of sprinklers, particularly in orchards, has resulted in better utilization of the surface soil. This is particularly true where cover crops are used and no cultivation is practiced.

A real advantage of the sprinkler method, especially where it is combined with a pipe distribution system, is the saving of land area. The land taken up by head ditches is not a very large percentage but may run about 3 per cent. The presence of such ditches is more important, however, than the mere area of land they take up indicates. They interfere with both cultivation and harvesting, they may harbor weeds and rodents, and they lose water. Corrugations in hay and grain fields also interfere somewhat with harvest operations.

In a minor number of instances sprinklers are advantageous in the possibility of making good use of small streams of water. Sometimes their use fits well into the farm labor schedule.

A decrease in the labor required has sometimes been claimed for the sprinkler method. Here again the matter is entirely relative. With well-managed semiportable systems, where laterals are moved once in 12 or 24 hrs, one man can cover about one acre per hour; with less efficient systems the requirement may be as much as 5 man-hours per acre. With surface methods, even greater variations in the labor requirement may be found. On row crops and sloping lands, an ordinary irrigator often will not successfully handle more than one cubic foot per second. This stream will apply one acre-inch per hour and 3 or 4 acre-inches generally constitute a single application. Under these conditions the labor requirement for application of water alone will be 3 or 4 man-hours per acre. At the other extreme of flat land and forage crops, one man may handle as much as 15 cfs and make applications of about the same depth. In those cases the labor requirement will be a small fraction of a man-hour per acre.

We come now to the most important disadvantage of the sprinkler method. That is its excessive initial cost. Certain costs are associated with sprinklers which are greater than the more or less corresponding costs for surface methods on lands and crops well adapted to the latter method. We can estimate these costs in a general sort of way.

The cost of installing a semiportable system such as we use in this part of the country will range from $40 to $100 per acre. Perhaps $75 is an average figure. This cost does not include the cost of the water supply delivered to the edge of the field. On the other hand, on land well suited to surface methods the cost of preparing land for surface irrigation, including the farm distribution system, may be on the order of $40 per acre. Of this $40 perhaps $10 will cover the cost of those structures that will need to be replaced in time. Now assume an interest charge of 3 per cent per annum, that the cost of repairs and maintenance is 3 per cent each year, and that the average life of sprinkler equipment or surface structures is 15 years. The annual cost for interest, maintenance, and depreciation then amounts to $9.50 for sprinklers as against $3.07 for surface methods. These figures include enough each year to pay for a new system when the old one wears out. They could be refined by assuming interest on the sinking fund or by some other means but that isn't worth while for the present purpose. The extra fixed cost of the sprinkler system as compared with the surface method is therefore $6.43 per acre per year.

To this we must add the cost of power for providing the pressure necessary for sprinkling. Assume that electric energy costs one cent per kilowatt-hour, that 40 psi is required at the pump, that the over-all efficiency of the pumping equipment is 60 per cent, and that 30 acre-inches of water is used. The annual power cost is $3.96 per acre with these rates. The net result is that on the basis of these assumptions, interest, depreciation, maintenance, and power will be something over $10 per acre per year more for sprinkling than for surface methods.

It would be nice if it were possible to say that sprinkling was or was not better than surface methods of irrigation. No such general statement is possible, and I am compelled, in spite of considerable study, to return to the conclusion I expressed almost two years ago in a paper in the "Reclamation Era." Where conditions are favorable for surface methods, in general, surface methods are more economical in labor and money and may be equally economical in use of water. Where conditions do not favor surface methods, sprinkling may be more economical in labor, money, and water. In any case each farm unit must be studied on its individual merits.

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2 *It may certify you as a part of management rather than labor.* If you are not a part of management (most engineers are not), then you definitely are a part of labor since there is no in-between class. Many engineers object to being required to join labor unions or find that membership in a union is detrimental to advancement. The Taft-Hartley law may recognize professional engineers as units of management, and consequently not required to join labor unions against their wishes.

3 *It helps elevate the "professional" standing of your profession.* Professional maturity of a profession — agricultural engineering, for example — comes only with the Professional maturity of its individual members. The Professional level of the Profession is the accumulated Professional levels of the individual members.

TO REGISTER

If you decide to register, write to the State Board of Registration for Professional Engineers and Land Surveyors at your state capitol for regulations and blanks.

Engineer in Training. Many state boards certify engineering graduates as engineers in training. Near the end of their senior year, they are given the opportunity to take the state examination on engineering fundamentals, if required. They are then issued an "Engineer in Training" certificate which places them in the "Professional Engineering" class. After the required period of experience has passed, they take the examination in their field of specialization and become a professional engineer. This procedure is recommended for graduating engineers since (1) they are associated immediately with "professional engineering," and (2) they can take the examination in engineering fundamentals when the fundamentals are fresh in their mind. Every graduating engineer should consider this step.

General information on registration in pamphlet and other form suitable for distribution to engineering students and others interested in registration can be secured from the National Society of Professional Engineers, 1359 Connecticut Ave., N. W., Washington 6, D. C., National Council of State Boards of Engineering Examiners, Columbia, S. C., and Engineers' Council for Professional Development, 33 W. 39th St., New York 18, N. Y.

This is the last of a series of four editorials sponsored by the ASAE Committee on Professional Registration — S. M. Henderson (chairman) and R. K. Frevert. The other three editorials appeared in the November and December, 1948, and the January issues of AGRICULTURAL ENGINEERING.

Uses and Limitations of Jet Water Systems

By George E. Trisler
ASSOCIATE A.S.A.E.

ON THE SUBJECT of jet pump uses and limitations, the same questions are being asked from coast to coast and border to border. How deep can we go with a jet pump? Will a jet pump deliver more water than some other kind of pump with the same size motor? Why not use a jet pump for all requirements? When should we not use a jet pump? How much pressure can be developed with a jet pump?

The so-called jet pump is a combination of the familiar centrifugal pump, either of the vertical or horizontal type, and an ejector. The ejector is placed at or below the water level in the case of deep-well installations, or built into the pump casing of a shallow-well jet. In either case the ejector is dependent on the pump for its operation, and the pump is definitely dependent upon the ejector to increase the total pressure or to lift the water from greater depths than 25 ft. The two are dependent upon each other and at the same time are helpful to each other in providing the over-all performance of a jet pump combination.

The accompanying illustration indicates the principle of jet pump operation. This shows a vertical centrifugal pump over a well with about 40 ft of pipe attached to the bottom of the pump. The centrifugal pump alone can not lift the water from the 35 ft level, nor can any other suction pump. All are limited on suction lift by atmospheric pressure. However, after the pipes are filled with water and the pump started, we can take part of the water from the discharge down through a hose to the nozzle at the lower end of the suction pipe that is submerged below the static level in the well. If the pressure from the hose was sufficient and the nozzle just the right size, the whole column of water would be moved up to within suction distance of the pump. The water from the nozzle passing through the restricted section at high speed causes a partial vacuum below the neck and a driving force above to push the water up to within suction distance of the pump. This is a jet pump in its simplest form.

The centrifugal pump is the one generally used with jet water systems because it is quiet and produces a continuous flow of water without pulsations. The centrifugal pump itself is usually of high efficiency, perhaps 60, 65, or even as high as 75 per cent. The ejector has a very low efficiency in comparison to that of the pump, probably around 25 per cent. It follows then that, if the ejector has only a few feet to lift water to the pump suction, the highly efficient pump really does most of the work and the result in over-all efficiency of the combination is quite satisfactory. However, the deeper the well the greater is the proportionate amount of work to be performed by the ejector, with a corresponding rapid decrease of over-all efficiency.

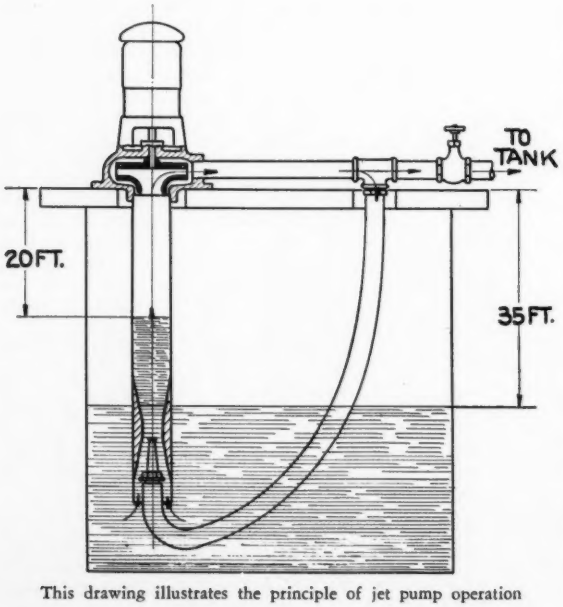
In order to arrive at some basis for limiting the use of a jet pump, we must consider other types of pumps which might overlap the jet pump field of service. First is the reciprocating pump with which we are all familiar. Assuming that all parts of such a deep-well or shallow-well unit are in good working order, we can be reasonably sure that at a certain speed a given size of cylinder will deliver a definite amount of water. This amount remains practically constant regardless of pressure or well depth. It is only necessary to put on a larger motor in order to get that extra pressure. There is still a definite need for reciprocating pumps in the range of medium and small capacities, for high pressures and for the deeper wells. By checking any manufacturer's catalog on jet pumps and comparing the performance with that of the reciprocating pumps made by that same manufacturer or any other pump company, it will be seen that the jet pump probably shows better performance than the reciprocating pump for wells 30 to 70 ft deep.

The smaller size jet pumps using 1/3 and ½ hp will invariably deliver more water at depths of 30 to 70 ft than can be expected from most any other type of pump of the same horse-power. These are probably the two most popular sizes of jet pumps. However, there are a great many ¾-hp and larger jets used with excellent results.

Let us consider some specific examples and compare performance of jet pumps and other types. These figures were not taken from any one manufacturer's catalog but some from manufacturers on the West Coast, some from eastern manufacturers and some from the manufacturers in the central and midwest sections. Suppose we want about 3 gpm or about 200 gpm from a well 90 ft deep, against 40 lb tank pressure. That would be 182 ft total head. A ½-hp reciprocating deep-well rod pump would probably be the most efficient and most practical to use if all conditions are equal. To supply the same performance with a jet pump would probably require a ¾-hp motor. That same ¾-hp jet, however, with a change of ejector, will produce 1000 gph or about 17 gpm from 40 ft in the well and deliver it to the tank at 30-lb pressure. The best that could be expected from the ½-hp rod pump with a change in the cylinder size would be about 7 gpm. To get the 17 gpm with a rod pump would require about 1½ hp. Table 1 gives other examples which show the performance of the two types quite well. *(Continued on page 90)*

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Portland, Ore., June, 1948 as a contribution of the Rural Electric Division.

George E. Trisler is assistant sales manager, The Deming Co., Salem, Ohio.



This drawing illustrates the principle of jet pump operation

TABLE 1

Type pump	Hp	Setting, ft	Tank pressure, psi	Total head, ft	Gpm	Gph
Rod	½	75	40	167	4.8	285
Jet	½	70	40	162	2.3	110
Jet	¾	70	40	162	4.5	270
Rod	¾	80	40	172	7.1	425
Jet	1	80	40	172	5.6	340
Rod	1	120	40	212	7.1	425
Jet	1½	120	40	212	4.5	270
Same jet pump with 20-lb tank pressure				166	5.3	302

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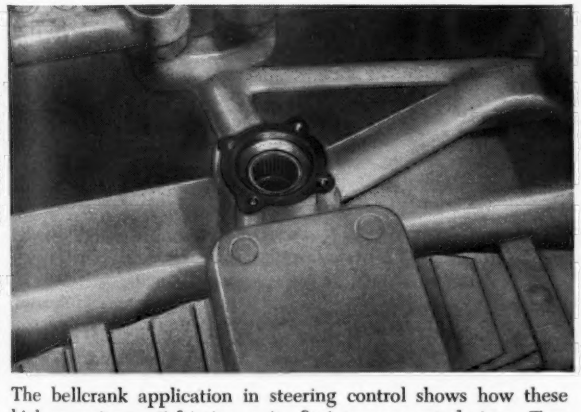
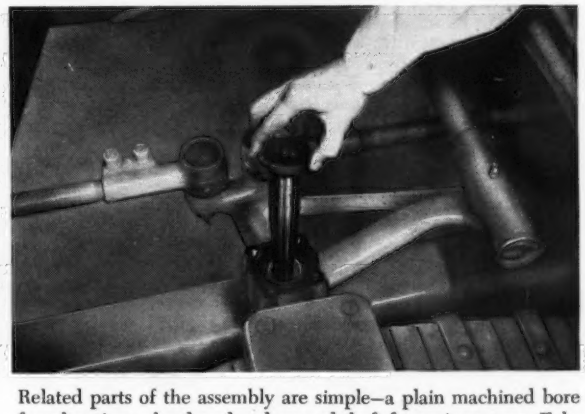


The bellcrank application in steering control shows how these high-capacity, anti-friction units fit into compact designs. Two Needle Bearings mounted with close fits keep mating parts in alignment. Freedom from wear maintains close bearing clearances and eliminates the need for readjustment.



Related parts of the assembly are simple—a plain machined bore for a housing, a hardened and ground shaft for an inner race. Fabrication is easy, and installation a quick arbor press operation. No retaining devices are needed. Such Needle Bearing features help keep manufacturing costs down.

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From these examples it is apparent that at about 70 to 80 ft in the well, the reciprocating or rod-type pump becomes more efficient and the cost of pumping water is less than with a jet pump. There are, of course, other considerations in the selection, but this gives us some definite figures on economical operation. Many other comparisons could be made with the same results, which seem to indicate that the greatest advantage of the jet pump will be on installations between 30 to 80 ft in the well and sizes up to 2 and 3 hp.

When we get into larger capacities, along with deeper wells, another type of pump enters the picture. That is the deep-well turbine which is really a multistage centrifugal pump with the several stages set close together and submerged in the water. The centrifugal-type pump, as we know, can be made highly efficient. This efficiency can be maintained in the multistage unit as used with the turbine pump.

A 5-hp jet pump may be capable of delivering 20 gpm at a total head of 280 feet. At that same pressure a 5-hp turbine pump would deliver about 40 gpm, or just about twice as much. A 5-hp rod pump could be expected to produce about 25 gpm at the same pressure. Possibly the same 5-hp jet pump would be capable of delivering the 40 gpm if the pressure were dropped to around 200 ft total head. At the low discharge pressure as required, for example, in flood irrigation where water is discharged at the ground level, the turbine shows a still greater advantage because the jet pump must always work under pressure in order to supply the nozzle of the ejector with the proper amount of water. This is true even though zero pressure is required after the water leaves the pump.

The shallow-well jet pumps have features of merit similar to the deep-well types. They follow the general characteristics of a centrifugal pump and deliver more water at low pressures. The shallow well jet drops off in capacity very rapidly with increased pressure. A comparison of shallow-well jet and reciprocating performance is readily seen in Table 2. Both pumps are equipped with a ¼-hp motor but the capacity of the jet exceeds the capacity of the reciprocating pump only at the 20 and 30-lb pressures, when pumping from a water level not over 15 ft from the pump.

TABLE 2

Suction, ft		Tank pressure 20 lb	30 lb	40 lb
		Capacity, gpm		
10	¼-hp shallow-well jet	530	530	345
	¼-hp reciprocating	375	375	375
15	¼-hp shallow-well jet	460	460	300
	¼-hp reciprocating	375	375	375
20	¼-hp shallow-well jet	370	370	240
	¼-hp reciprocating	375	375	375

The ¼-hp reciprocating pump can also be used up to a 22-ft suction lift and at pressures up to 50 lb with practically the same capacity on the delivery side. The loss in capacity for the shallow-well jet pump at the higher pressures is normal and the capacity also drops off with the higher suction lift.

From these comparisons it is apparent that the limitations of jet pumps are not confined to hydraulic possibilities, because jets can be made to pump from very deep wells and can also produce large capacities against high pressure. It is rather a matter of economical limitations. Economical operation, that is, cost per thousand gallons of water pumped, is not always a deciding factor. Every purchaser places values on certain factors in terms of his local condition and perhaps previous experiences which may counteract or overshadow the economic factor. Any one of the following may be first in the mind of the buyer:

1 Availability of parts and service when needed

2 Cost of service and length of time required to do the work (how long he will be without water in case of trouble)

3 First cost and installation cost

4 Mechanical efficiency — cost of pumping each 1000 gal of water

5 Pump location. (If pump must be located away from the well, then a jet pump must be used regardless of cost or upkeep.)

6 How much noise does it make? The deep-well turbine is probably the most quiet of all. The jet pumps are considered quiet by most people, but frequently the characteristic noise of a jet pump is most annoying to a purchaser who may not object at all to the tapping noise of the valves in a reciprocating pump.

During the rise of jet pump popularity throughout the country there were some distributors and even some manufacturers who thought that the jet pump was going to replace all other types. There is not that same feeling of absolute replacement today. The following figures on production are taken from the Bureau of Census reports and may be indicative of the thinking, particularly among dealers and service men:

SUMMARY OF WATER SYSTEM PRODUCTION, INCLUDING BOTH SHALLOW-WELL AND DEEP-WELL PUMPS

	1944	1945	1946	1947
Jet	115,627	175,652	318,758	361,140
Non-jet	200,758	214,478	306,971	401,715

During 1947 there were 14,922 fewer deep-well jets made than in 1946, and during the same period there was an increase of 21,448 in non-jet deep-well pump production. The deep-well jet production, however, was still much greater than the non-jet type, but the census figures show that there was an increase in the number of non-jet water systems produced for the deep well, and a decrease in the number of jet water systems for deep wells over the preceding year.

In the shallow-well type the non-jet still leads in the number of water systems being produced, and the census figures show production as follows for 1947:

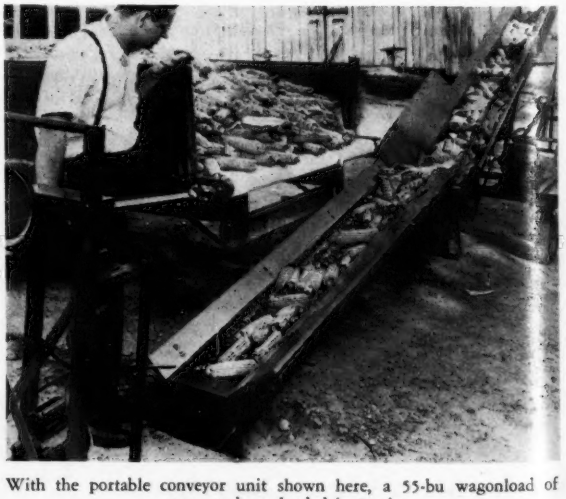
Shallow-well jet water systems	116,141
Non-jet shallow-well water systems	341,566

The totals for the first three months of 1948 show the following:

Jet water systems, both shallow and deep-well	83,670	46 per cent
Non-jet water systems, both shallow and deep well	97,568	54 per cent

While jet pumps represented one-quarter of the water system production in 1941, they were over one-half the total production in 1946 and but slightly less than one-half in 1947.

Jet water systems cannot be expected to replace all other types of pumps and can maintain their present popularity only if they are properly applied, carefully selected, and carefully installed by competent dealers.



With the portable conveyor unit shown here, a 55-bu wagonload of corn can be unloaded in 5 min

Johns-Manville Asbestos Flexboard is STRONG AND TOUGH

One man can handle the big sheets

Exclusive J-M manufacturing process makes this fireproof, rotproof building board so strong and tough that it can be lifted and handled by one man without cracking or breaking. You save on time and labor, and avoid waste.

It can be nailed close to edge

Another advantage of Flexboard—you can drive a nail even close to the edge of the sheet without cracking or chipping . . . no drilling required!

It bends to fit curves

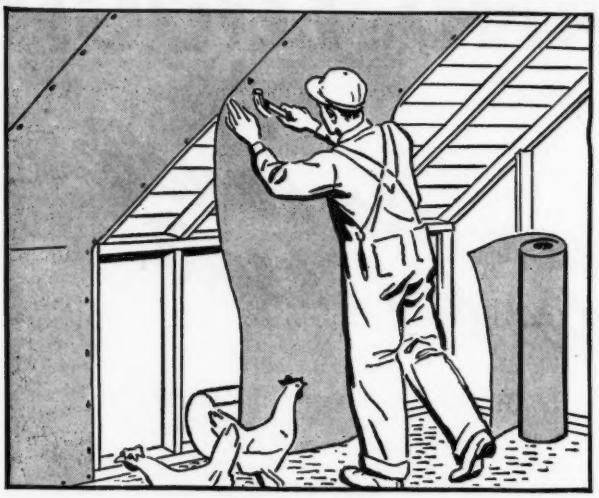
Send for FREE Handbook, "Flexboard on the Farm"— Illustrates how farmers throughout the country are using this revolutionary building board on many types of projects; shows how to cut it, work it, apply it indoors and out; includes many installation photographs. Address Johns-Manville, Farm Division, Box 290, New York 16, N. Y.

Still another exclusive feature . . . Flexboard is so tough and flexible it can be bent on either axis to a degree unmatched by any other product of its kind . . . a great advantage where curved surfaces are required.

Flexboard is a Johns-Manville registered trade mark

JOHNS-MANVILLE JM PRODUCTS

HELPING THE AMERICAN FARMER DO A *BETTER* JOB



SISALKRAFT "CASE HISTORIES" OVER A PERIOD OF 20 YEARS IN THE FIELD OF PRACTICAL RESEARCH

Lining Poultry Houses and Other Farm Buildings

From the earliest days of SISALKRAFT on the farm, this tough, strongly reinforced, waterproof, windproof paper product has been used for lining poultry houses, brooder houses, range shelters, etc. Applied to inside studs, SISALKRAFT shuts out wind and moisture, and helps simplify control of ventilation . . . helps keep poultry houses warmer in cold weather, drier, more healthful for the flocks.

SISALKRAFT Practical Research has been continuous . . . aiming always to help the American farmer to do a better job, economically . . . as evidenced by many similar achievements of SISALKRAFT on the farm.

Today, another SISALKRAFT product . . . SISALATION . . . is proving successful as an inside lining for poultry houses. The aluminum surfaced SISALATION is a vapor barrier and insulation combined. SISALATION keeps houses about 15° cooler in summer.

Should you have a problem where a remarkably strong, waterproof paper might be helpful, write Dept. AE

The SISALKRAFT Co.
205 W. Wacker Drive, Chicago 6, Ill.
SISALKRAFT Products are sold by Lumber Dealers throughout America.

NEWS SECTION

A.S.A.E. Meetings Calendar

March 17 to 19 — MID-CENTRAL SECTION, Kansas State College, Manhattan.

April 15 and 16 — SOUTHWEST SECTION, Grim Hotel, Texarcana, Tex.

April 15 and 16 — VIRGINIA SECTION, Hotel Roanoke, Roanoke, Va.

June 20 to 23 — ANNUAL MEETING, Michigan State College, East Lansing, Mich.

October 6 to 8 — PACIFIC NORTHWEST SECTION, Harrison Hot Springs Hotel, Harrison Hot Springs, B. C.

December 19 to 21 — WINTER MEETING, Stevens Hotel, Chicago, Ill.

Martin Ronning Chairman of Minnesota Section

AT THE annual dinner meeting of the Minnesota Section of the American Society of Agricultural Engineers held Thursday evening, January 20, at the Dyckman Hotel in Minneapolis, Martin Ronning, chief engineer, power machinery division, Minneapolis-Moline Power Implement Co., was elected chairman of the Section for the ensuing year, succeeding John A. Schaller, advertising manager, Rilco Laminated Products, Inc. Marvin Nabben, agricultural engineer, Northern States Power Co., who served the past year as secretary-treasurer, was elected the new vice-chairman of the Section, and Curtis L. Larson, a member of the agricultural engineering staff, University of Minnesota, succeeds Mr. Nabben as secretary-treasurer. Charles K. Otis, also of the University of Minnesota's agricultural engineering staff, was elected a director of and the Section representative to the Minnesota Federated Engineering Societies, with which the Section is affiliated; and Mr. Schaller was elected alternate director of the MFES.

M. J. Samuelson, mechanical engineer, tractor division, Minneapolis-Moline Power Implement Co., was elected to the new post of contributing editor of the Section.

W. H. Kircher, field editor, "The Farmer", presided as toastmaster for the entertainment following the dinner. Following a very clever and entertaining ventriloquist act, Toastmaster Kircher introduced ASAE President Arthur J. Schwantes, who gave an interesting account of his trips to various ASAE section meetings, to Washington, and to Student Branch meetings during the first half of his term as president.

The principal speaker of the evening was V. S. Peterson, manager, central west district, extension division, E. I. duPont de Nemours & Co., who discussed the subject of research and chemurgy and its particular implications for agricultural engineers.

Agricultural Engineering Presented in Career Conference

AGRICULTURAL engineers shared in a Chicago Area Career Conference held December 28, 29, and 30 by the Chicago Technical Societies Council, the Chicago Sun-Times, and Illinois Institute of Technology at the Technology Center of the Institute.

The Conference was primarily for high school seniors, and offered information and guidance on the various branches of engineering and other professional and technical fields.

Agricultural engineering was checked as a field of interest on 61 coupons turned in on advance registration for the conference. Unfavorable weather reduced attendance but 26 showed up for the two scheduled counseling sessions on agricultural engineering. W. C. Dean was the speaker at one of these sessions and C. N. Hinkle at the other. Both men are members of ASAE, and of its Chicago Section which has membership in the CTSC. Each gave an introductory talk on the nature of agricultural engineering, its history, educational requirements, and fields of employment. This was followed by a question and answer period. Keynote addresses by representatives of business and professional fields were another feature of the conference program.

This year's conference was the first attempt of the sponsoring organizations at offering a program of this type to high school seniors in the Chicago area.

West Virginia to Register Ag Engineers

IT IS reported that at a recent meeting of the West Virginia Registration Board for Professional Engineers, all existing classifications for registration were repealed, and in place thereof 15 different engineering classifications were authorized, in which agricultural engineering was included as a separate classification.

(News continued on page 94)

ALLIS-CHALMERS SPECIFIES NICKEL ALLOY STEELS for

New Farm Tractor Powered By Rear-Mounted Engine

This new and low priced Allis-Chalmers model "G" tractor with rear-mounted engine, drives front-mounted, quick-hitch, companion implements.

It provides an unsurpassed range of visibility. In addition it assures long, dependable performance by utilizing nickel alloyed steels for many vital parts.

The extra stamina provided by alloy steels containing nickel offers sturdy resistance to shock loads, sudden power demands and other high stresses. Accordingly engineers of Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin, specify nickel alloyed steels for the following important parts:

PART	NICKEL ALLOYED STEEL	HARDNESS
Transmission Countershaft	Type A-4817	58-63 RC
Differential Pinion Pin	Type 4620	25 min RC
Transmission Stud	Type 3140	241-281 BHN
Intake Valves	Type 3140	50-60 Scler
Differential Ring Gear	Type 8620	58-63 RC
Belt Pulley Shaft	Type 8620	58-63 RC
Connecting Rod Bolts	Type 8640	286-321 BHN
Cylinder Head Studs	Type 8640	269-302 BHN

High mechanical properties make nickel alloyed steels especially suited for use in farm equipment. Write for recommendations regarding the best types for your applications.

EMBLEM OF INCO SERVICE
TRADE MARK

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Specify

TUTHILL MODEL 5-W

The Pump for Your Weed and Pest Control Equipment

No other pump for tractor spraying outfits combines these practical advantages of the Tuthill Model 5-W in one compact unit:

- Direct-mounted on power take-off.
- Adaptable to pulley drive.
- Compact . . . close-coupled design. Over-all dimensions . . . 4½" x 5½" x 6⅜" . . . Net weight 12½ lbs.
- Fits 1⅛" or 1⅜" spline shafts.
- Pressure range from 0 to 300 pounds per square inch.
- Delivers 5 g.p.m. at 100 p.s.i. at 550 r.p.m.; 16 g.p.m. at 100 p.s.i. at 1750 r.p.m.
- Built of highly corrosion-resistant materials to handle a wide variety of spray liquids.
- Self-priming . . . self-lubricating.

Write for complete details.

TUTHILL PUMP COMPANY

939 E. 95th Street, Chicago 19, Ill., Phone REgent 4-7420

NEWS SECTION *(Continued from page 92)*

Hydraulic Control Standard

THE proposed ASAE Standard on the Application of Hydraulic Remote Control to Farm Tractors and Trailing-Type Farm Implements, published on pages 17 to 19 of AGRICULTURAL ENGINEERING, for January, has now been submitted to letter ballot to corporate members of the American Society of Agricultural Engineers. The adoption of this standard as an official ASAE Standard will be completed next month.

Movie on Farm Fires

THE National Association of Mutual Insurance Companies announces the release and availability of its sound film production, "Outlawing Farm Fires." The theme of this 23-min, 16-mm movie is Fire Prevention by Inspection. Throughout the movie, the actual farm scenes depict hazards which are common to most farmsteads. Such conditions as faulty wiring, hazardous heating installations, improper storage of flammable liquids, defective lightning-protection equipment, and other unsafe structural features are discussed and illustrated. In addition to highlighting the common hazards, it presents methods of eliminating such conditions by the farmer himself through constant vigilance and an interest in fire prevention. The film also describes an inspection system which has aided in reducing the annual fire loss in one state by 50 per cent.

The film was based on facts obtained through past research investigations by the Iowa Agricultural Experiment Station under the immediate direction of Prof. Henry Giese, in cooperation with the Farmers Mutual Reinsurance Co., Grinnell, Iowa. These results are illustrated by simple charts and graphs.

This movie, produced primarily for farm audiences and particularly adapted for use with vo-ag students, 4-H clubs, farm groups, etc., is available from the National Association of Mutual Insurance Companies, 2105 N. Meridian St., Indianapolis 7, Ind.

New England's 10th Farm Electrification Institute

THE Tenth New England Farm Electrification Institute has been scheduled for April 13-16 with the University of Maine, at Orono, serving as host to the group.

Program subjects tentatively scheduled include farm and home lighting; application of incandescent, fluorescent, germicidal, and infrared lamps; irrigation; potato house ventilation; adequate farm wiring; developments on the heat pump; commercial freezing and packaging, and poultry house ventilation.

Some of the speakers announced are J. P. Ditchman, Miss Edith Buchholtz, J. B. Steere, Geo. W. Kable, A. K. Gardner, H. N. Stapleton, Frank Reed, Clayton Osgood, Nathan H. Rich, and Merle S. Klinck.

One feature of the Institute will be a banquet Thursday evening, April 14, with Maine's Governor Frederick G. Payne as speaker.

Registration is to begin at the Bangor House Wednesday noon, April 13. Most of the meetings will be held in the new library building centrally located on the University of Maine campus. Meetings begin at 9:30 a.m. Thursday.

A limited amount of space will be available to manufacturers for exhibits of new equipment. Interested manufacturers may obtain further information from E. W. Foss, agricultural engineer, Extension Service, University of Maine, Orono.

Entertainment for accompanying ladies will be provided on Thursday and Friday afternoons. An interesting tour of a pulp and paper mill is planned for Saturday.

Reservation of accommodations for the meeting may be made at either the Bangor House or the Penobscot Exchange hotels.

The Farm Electric Service Committee of the New England Council, which sponsors the Institute, will hold a meeting Friday evening at the Bangor Hydro Assembly Hall.

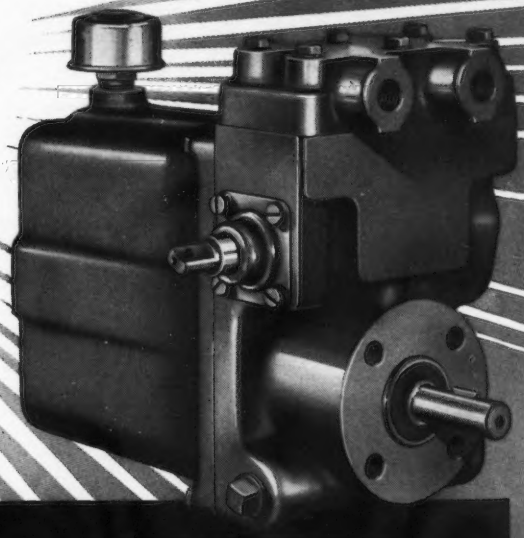
Necrology

FRED O. YENNY, director of education and service for the Triad Tractor and Implement Corp., at Utica, N. Y., passed away at his home September 25, 1948. Born at Onandaga, N. Y., June 10, 1897, he studied farm mechanics at LaSalle Institute, and in 1918 became service manager for the Syracuse, N. Y., Branch of the J. I. Case Co. In 1941 he became a regional service manager for Harry Ferguson, Inc., in the same general area, and later transferred to the position held at the time of his passing. He was elected to membership in the ASAE in 1944, and was also a member of Woodmen of the World. He is survived by his widow, Gertrude Kiley Yenny, two sons, a brother, and three sisters. Burial in St. Agnes Cemetery followed funeral service in St. Michael's Church.

"PACKAGED HYDRAULICS"

MANY ADVANTAGES

MANY USES

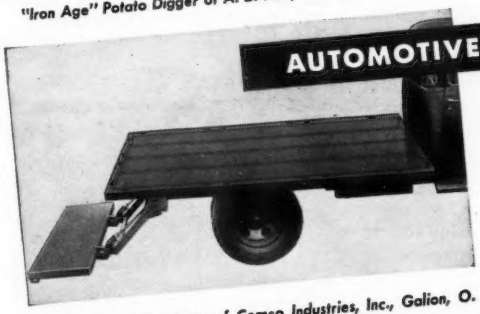


VICKERS POWER PACK

AGRICULTURE

"Iron Age" Potato Digger of A. B. Farquhar Co., York, Pa.

AUTOMOTIVE



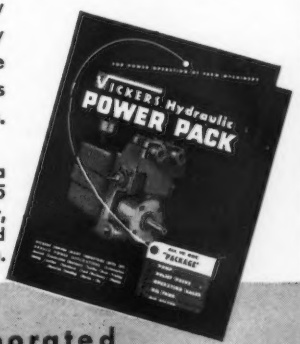
"Hydraul-Lift" Tail Gate of Cemco Industries, Inc., Galion, O.

CONSTRUCTION

"Profit Mover" of Construction Products Corp., Lynwood, Calif.

The Vickers Hydraulic Power Pack is a compact, self-contained hydraulic system which meets a wide variety of control needs in mobile equipment. It provides the machinery equipment manufacturer with a quick, easy, low cost installation which assures his customers of long trouble free service.

Tractors, planters, cultivators, plows, stackers, loaders, harvesters, rakes, mowers, etc., are among the many agricultural uses for the Vickers Hydraulic Power Pack. On commercial vehicles, it saves time and labor by actuating dump hoists, lifting tail gates and other miscellaneous operations. In the construction industry, light duty scrapers and bulldozers, fork lift trucks, loaders, scoops, snow plows, tractors, etc., are conveniently and economically controlled by the Vickers Hydraulic Power Pack. It saves labor, speeds operation, cuts costs.



The Vickers Hydraulic Power Pack is a compact package weighing only 55 pounds. It incorporates an oil tank, filter, vane pump, overload relief valve and operating valve. Write for Bulletin 46-48a.

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DIVISION OF THE SPERRY CORPORATION

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Baker, Ervin R., Jr.—Instructor in rural electrification, West Virginia University, Morgantown, W. Va.

Barisone, Renato L.—Leechburg, Pa.

Barrios-Ferrar, Rafael—Distributor, Santa Marta, Colombia, S. A.

Bohnenblust, Gene F.—Agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 408, Lyons, Kans.

Bryant, Joseph R.—Assistant county agent, Agricultural Office, Box 1, Elizabethtown, N. C.

Darnell, Shapley B.—Sales engineer, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee, Wis.

Davenport, Marc G.—Assistant agricultural engineer, Texas Agricultural Experiment Station, Beeville, Tex.

Gardiner, Gordon H.—Farmer, Box 513, Regina, Sask., Canada.

Hancock, Thomas E.—District manager, Florida Ford Tractor Co., Jacksonville, Florida.

Johnson, Carlton E.—Instructor in agricultural engineering, Iowa State College, Ames, Iowa.

McInnis, Laurin A.—Assistant agricultural engineer (research) Clemson Agricultural College, Clemson, S. C.

Miller, Donald F.——Teacher, Bentley High School, Bentley, Kans. (Mail) Box 94.

Nelson, Glenn S.—Instructor in agricultural engineering, A. & I. College of Texas, Kingsville, Tex.

Phillips, S. B., Jr.—Agricultural representative, West Texas Utilities Co. (Mail) San Angelo, Tex.

Rae, Robert M.—Graduate assistant in agricultural mechanics, University of Saskatchewan, Saskatoon, Sask., Canada. (Mail) 1115 Elliott St.

Renoll, Elmo S.—Agent, Bureau of Plant Industry, Soils and Agricultural Engineering, USDA. (Mail) Agricultural Engineering Dept., Iowa State College, Ames, Ia.

Rogers, Ernest B., Jr.—Assistant professor of agricultural engineering, Clemson Agricultural College, Clemson, S. C.

Rutledge, J. P., Jr.—Sales representative, New Holland Machine Co. (Mail) Apt. 5, 700 16th St., Knoxville, Tenn.

Sanders, Joe T.—Engineer, Soil Conservation Service, USDA. (Mail) Box 563, Navasota, Tex.

Sorensen, Knud B.—Chief engineer, John Deere Wagon Works, Moline, Ill.

Spencer, Richard B.—Fieldman, Pet Milk Co., Mayfield, Ky.

Tosello, Andre—Head, department of engineering, State of S. Paulo, Rua Sacramento—1080, Campinas, Brazil, S. A.

Viswanathan, P. S.—Chief agricultural engineer, Government of the United Provinces, Agricultural Gardens, Nawabgauj, Kanpur, India.

Weaver, Harrison, Jr.—Chief engineer, Brillion Iron Works, Inc., Brillion, Wis.

Webb, Charles H.—Assistant county agent, Dadeville, Ala.

Wennblom, Ralph D.—Associate editor, Farm Journal, Washington Square, Philadelphia 5, Pa.

Wilkes, Lambert H.—Instructor in agricultural engineering, Texas A. & M. College, College Station, Tex.

Young, Paul A.—Associate director procurement and producer relations, National Dairy Products Co., Inc., 75 E. Wacker Dr., Chicago 1, Ill.

TRANSFER OF GRADE

Adkins, A. E.—Chief engineer, Athens Plow Co., Athens, Tenn. (Junior Member to Member)

Bailey, Frank R.—Director, farm service div., Central Main Power Co., 9 Green St., Augusta, Maine (Associate to Member)

Kenney, W. D.—Assistant agricultural engineer, Coastal Plain Experiment Station, Tifton, Ga. (Junior Member to Member)

Osterloh, Bernard—Retail farm implement dealer, Lepp & Osterloh, Gothenburg, Nebr. (Junior Member to Member)

Rogers, John A.—Blockman, Allis-Chalmers Mfg. Co. (Mail) 320 W. Walnut St., Troy, Ala. (Junior Member to Member)

Ulich, Willie L.—Extension agricultural engineer, A. & M. College of Texas, College Station, Tex. (Mail) Box 284 (Junior Member to Member)

BENDIX-PACIFIC standardized cylinders meet the specifications and requirements of the farm equipment industry and are being used by several tractor manufacturers.

Through the use of seamless tubing and advanced manufacturing techniques these cylinders are lighter in weight and cleaner in design, materially aiding in the lifting, handling and attaching required in their use. The heads are designed so that they can be rotated to any position, permitting plumbing connections to be made from any side or angle.

These cylinders are competitively priced. They can be furnished with mechanical or hydraulic depth stops.

Bendix-Pacific also is building many other types of cylinders and offers its engineering facilities to assist with your cylinder design requirements, or will quote on designs to your specifications. In the past hydraulic cylinders of all types . . . this extensive experience and manufacturing know-how can produce reliable low-cost cylinders for you.

Detailed information will be gladly furnished on these cylinders and other Industrial Hydraulic Equipment on request.

Bendix Pacific
INDUSTRIAL HYDRAULICS
PACIFIC DIVISION, BENDIX AVIATION CORPORATION
NORTH HOLLYWOOD, CALIFORNIA
Sales engineering offices in New York and Chicago

OLIVER "66"-"77"-"88"

3 New Farm-Utility Leaders!

Here's a new Oliver tractor trio that *fits your farm* better—provides greater power flexibility and operating efficiency than you've ever before experienced.

For the first time, here's a new tractor fleet with identical utility features and performance advantages. These practical new Oliver tractors differ only in size. Just pick your power for the jobs to be done from these three great new models—the snappy 2-plow, 4-cylinder "66" . . . the smooth 2-3 plow, 6-cylinder "77" . . . and the powerful 3-4 plow, 6-cylinder "88"—built in Standard and various Row Crop types.

Stop at the sign of the Oliver Shield for all the facts on the newest . . . and the finest in farm power.

OLIVER

THE OLIVER CORPORATION

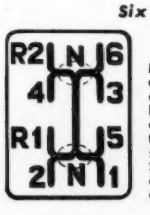
"FINEST IN FARM MACHINERY"

The OLIVER Corporation
400 West Madison St., Chicago 6, Ill.

Direct Drive Power Take-Off

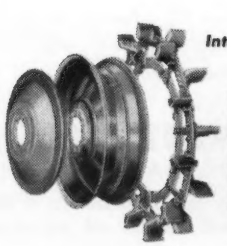
Saves time . . . increases efficiency of power take-off machines. P.T.O. unit driven directly from engine. Controlled by separate clutch. Standard equipment on *all three* new Oliver tractors at no additional cost.

Six Forward Speeds

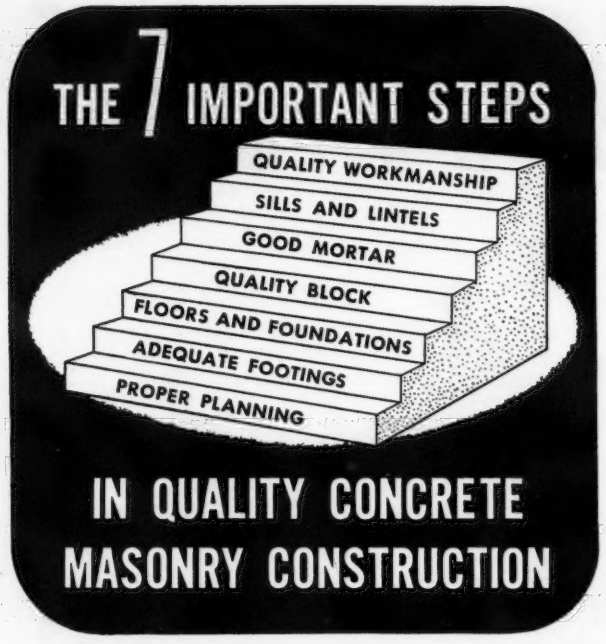


Money saver! Gives you almost any ground travel and draw-bar pull combination you need, at an operating economy that adds up to substantial savings in fuel. Standard equipment on *all three* models at no extra cost.

Interchangeable Rear Wheels



Choice of cast iron or stamped steel wheels to fit your traction and weight requirements—interchangeable among *all three* new Row Crop models. Standardized rim takes wide range of tire sizes. Tip Toe steel wheel attachment for cast iron wheel is available.



THERE are seven important steps in the construction of any concrete masonry farm structure. Careful attention to these seven factors will result in strong, durable and weather-tight buildings:

1 **PROPER PLANNING** as to the intended use of the structure, its geographical location and the special requirements of the building site.

2 **ADEQUATE FOOTINGS** placed on firm earth to ensure lifelong service and stability.

3 **FLOORS and FOUNDATIONS** of concrete—floors for labor-saving service and for keeping out vermin; foundations for strength and rigidity.

4 **QUALITY BLOCK** that comply with A.S.T.M. specifications for compressive strength, water absorption and moisture content.

5 **GOOD MORTAR** for durable joints, using full face shell bedding and compacting the mortar to ensure weathertight construction.

6 **SILLS and LINTELS** for all door and window openings. Lintel reinforcement should be designed for the load to be carried.

7 **QUALITY WORKMANSHIP.**

Illustrated bulletins on all phases of quality concrete masonry construction are available free. Distributed only in the United States and Canada.

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Dept. A2-1, 33 W. Grand Ave., Chicago 10, Ill.

A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

USDA Notes on Porous Concete, Labor Saving in Dairies, Protecting Winter Fruit, Cotton Harvesting

Porous Concrete Tested. E. G. Molander, in charge of the construction materials and methods project, Division of Farm Buildings and Rural Housing, has received from the Bureau of Standards a report on tests of plain and reinforced porous concrete slabs to determine the rate of air passage through them and the transverse strength. Bureau engineers are interested in the possibilities of this material for false floors in corn cribs or bins where artificial drying with forced air is to be used. Slabs made of a mixture of 9 parts of ¾-in gravel to 1 part cement had a load-bearing capacity of from 600 to 1,000 lb per sq ft when tested on a 20-in clear span, and the air flow through the slabs was high enough for satisfactory drying of corn in cribs with heated air. The Division plans to test the material in actual field construction and use. For the laboratory testing by the Bureau of Standards, Mr. Molander prepared 24 slab specimens 24 in square, 3 in thick, and weighing about 100 lb each. Some specimens were plain, some reinforced with plain wire in various patterns, and some with barbed wire.

Labor Saving Methods in Dairies. Harry L. Garver, agricultural engineer in charge of methods engineering, and Thayer Cleaver, who is stationed at Urbana, Illinois, have prepared a paper on simplifying dairy chores for the 12th International Dairy Congress, to be held at Stockholm, Sweden, next August. The recommendations made for efficient work methods, design and arrangement of buildings, kind and type of equipment and tools and their arrangement are based on findings in a study of 50 dairy farms in Illinois, Wisconsin and Indiana.

Estimates of the proportion of the dairyman's time occupied in and around the buildings range from around 65 to 80 per cent. Most of this time is spent in doing repetitive chores. How carefully thought out building design and arrangement can contribute to labor saving is shown by the before-and-after-remodeling-story of one barn. After improvements one man milked one cow more than were milked by two before and took only 6.7 minutes longer than both of them used to take.

Farm Machinery Mission. Roy B. Gray, chief of the Farm Machinery Division, is back from 2½ months in Europe as a member of a mission appointed by Secretary Brannan at the request of Economic Cooperation Administrator Paul G. Hoffman to study the farm machinery needs in ERP countries. The mission was headed by M. A. Sharp, head, agricultural engineering department, University of Tennessee. Mr. Gray visited the following ten countries: France, Holland, Denmark, Germany, England, Itally, Tunisia, Algeria, Greece, and Turkey. Some of these were the same countries he was in during the years 1910-20, when he was with the International Harvester Co., and again in 1936, when he made an exploratory trip for the Bureau of Agricultural Engineering. During the last thirty years, Mr. Gray observed, there have been changes in the distribution of farm machinery types. The two-plow tractor was popular in England around 1910, whereas now many English farm operators are interested in larger tractors of the track-laying type. In Germany, on the other hand, large tractors were more in demand in the 1910-20 period than now. The Germans' idea now is for a tractor that in addition to field work can haul trailer loads of sugar beets, for instance, along the highways.

Throughout most of the agricultural regions he visited, Mr. Gray found an interest in deep plowing. Citrus and olive growers in Italy and North Africa plow three feet deep. Two-foot plowing is used in some sections of England to loosen and serate the soil, in parts of Italy to provide underdrainage for subterranean springs. Wheat acreages in Africa and Turkey are often plowed 10 to 12 in deep. The climate is semiarid and the ground hard. Plowing is done right after harvest to take advantage of the September rains. Before planting root crops, many European farmers plow 3 times — first about 3 in deep to kill weeds, then 6 or 8 in deep, and finally 10 or 12 in deep.

Protecting Winter Fruit Shipments. BPISAE findings in extensive tests on the transportation of apples and pears from the Pacific Northwest were presented by Edwin Smith and Walter H. Redit before an Interstate Commerce Commission hearing in Seattle, October 25 and 26. The hearing dealt with ICC protective service orders on winter shipments of the fruit. The 114-page illustrated report by the Bureau covering 6 tests with 51 cars was made a part of the record.

During the past 2 years, Smith and Redit have conducted a study to find methods of protecting the fruit *(Continued on page 100)*

A Gorgeous Sight? It's Wasteful Farming

To the man who loves the soil, there's no sight more gorgeous and yet more sad than a sloping field of checked-row corn.

He sees deeper than the never-ending pattern of crisscrossing green lines up and down the slopes. Instead, he sees the furrows as gutters that gather and speed rainfall, carrying off in hours precious topsoil that took Nature hundreds of years to build.

Conserving our land is basic. For when our land goes, our wealth goes . . . and our nation. History proves this in a thousand different ways.

Conservation isn't a matter of patriotism. It's good business and good farming. It is treating the land according to its needs and using it to best advantage.

This does two things. It looks to the future so that our sons and their sons receive the land in as good, if not better condition than when we received it.

But it also pays dividends here and now. For instance the corn field above. Drilling that field on the contour would have meant easier and faster planting, easier cultivating, easier picking at harvest . . . and almost invariably, bigger yields.

It's already later than we think. Too much topsoil has already been lost. Saving what we have left is a job for all — for us who make the farm machinery as well as those who use it.

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RESEARCH NOTES

(Continued from page 98)

from freezing without overheating during transit. They tested eight new types of thermostatically controlled alcohol and charcoal heaters developed as a result of earlier work in the Bureau.

On the basis of their findings, they recommend the use of thermostatically controlled non-fan heaters in cars equipped with air-circulating fans. This equipment provides uniform temperatures and prevents overheating of fruit on the top of the load. In the old type non-fan car, the thermostatically controlled charcoal heaters operated under present rules (based on outside air temperatures) provided almost as satisfactory protection as the fully automatic alcohol heaters.

Cotton Harvesters — The main progress in mechanization is the trend to mechanical harvesting. Last year between 70 and 80 cotton pickers of the spindle type were used in California. This year there may be five times as many.

California is well suited to mechanization. Its fields are large and level and its farmers are accustomed to using power machinery. Weather conditions are generally favorable. High average yields per acre of cotton in the state make for large output per machine per hour.

Weed and grass control is one of the major problems in mechanization, not only in labor costs but in its influence on mechanical picking.

Flame and sprays supplementary to cultivation have been tried but a definite answer is elusive. In the matter of flaming and spraying, the equipment industry is ahead of the plant physiologists and chemists. Flame and grass sprays can be applied if the chemists and plant scientists will tell what to use, when and how much.

There may be days or even weeks on end when the humidity is so low that the usual defoliants do not work well. The solution for that problem lies with the chemists and the plant scientists to a large extent, though the engineers may have a job to do on applicators which will thoroughly cover the foliage with an optimum range of particle sizes.

When labor is saved by mechanization many people must be trained to operate and repair the machines. The driver of a four-row tractor cultivator must have far different training than the man who operates a hand hoe. The same is true for flame weeders. The purpose of cotton mechanization will be defeated if mechanical cotton pickers are operated by untrained and careless men.

NEWS FROM ADVERTISERS

New Products and Literature and Business Changes Announced by AGRICULTURAL ENGINEERING Advertisers

Two-Row High-Speed Potato Planter (International Harvester). It is specially equipped with operator's seat and row markers. The ground-working units are raised and lowered hydraulically by the tractor operator. Increased capacity seed and fertilizer hoppers are also a feature.

The new planter will be supplied only on 7.50x24 pneumatic tires, and fertilizer units, formerly sold as attachments, will be supplied as integral parts of the planter.

Another important feature is the provision for raising and lowering the wheels of this planter by means of adjustable stub axles. This adjustment regulates the planter's height for either flat planting or bed planting.

The high-speed pickup mechanism consists of two six-arm picker wheels per row. The picker wheels are set at an angle in the picker chamber, the V-shape arrangement assuring positive, accurate spacing and the elimination of bridging.

International Harvester high-speed potato planter

A CORRECTION

The caption for the illustration at the bottom of page 16 of AGRICULTURAL ENGINEERING for January, 1949, should have read as follows: "John Deere Model R Diesel Tractor pulling a moldboard plow."

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As a farm technical advisor, you will be consulted more and more frequently on farm welding. Can you rattle off the right answers . . . give the farmers of your community real help with their welding problems?

The new Westinghouse Farm Welding Bulletin, just hot off the press, will give you the answers to many of these problems. It brings you up to date on the latest welding procedure and techniques . . . shows how to build time and money-saving devices for the farm. Your free copy is ready . . . mail this coupon today. J-91727

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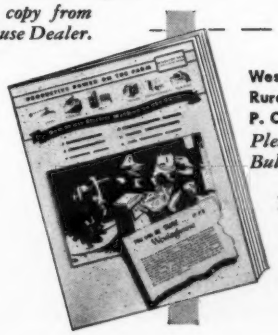

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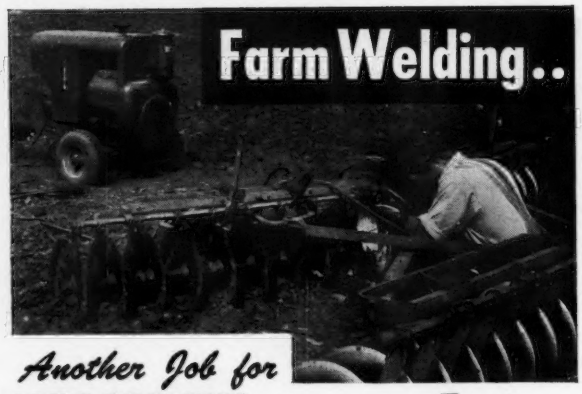

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This farmer-owner tows his mobile 200 amp. "Shield-Arc Junior" D.C. Welder, manufactured by The Lincoln Electric Company, Cleveland 1, Ohio, directly to the scene of breakdown. Handy and economical for small or large farm repair jobs, the generator of this unit is rated at 200 amperes with a normal welding current range of from 40 to 250 amperes.

All-weather, heavy-duty power is supplied by a 4-cycle, 4-cylinder, model VF-4, Wisconsin Air-Cooled Engine, rated at 22 hp. at 2100 r.p.m. . . . another typical example of power in the 2 to 30 hp. range where Wisconsin 4-cycle singles, 2-cylinder, and V-type 4-cylinder engines are specified for all types of equipment built by several hundred manufacturers.

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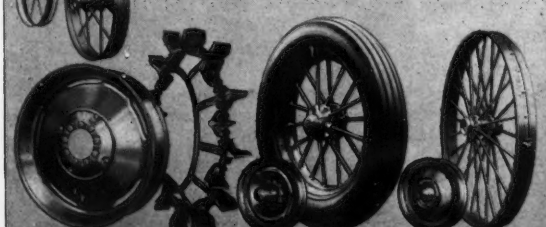

ELECTRIC WHEEL CO., 2908 Pine, Quincy, Ill.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: 1948. APRIL—O-615. JULY—O-627, 629, 630. SEPTEMBER—O-641. NOVEMBER—O-650, 651, 652. 1949. JANUARY—O-654, 655.

POSITIONS WANTED: 1948. MARCH—W-146,. APRIL—W-158. AUGUST—W-184, 189. NOVEMBER—W-196, 197, 199, 202, 203, 204. DECEMBER—W-206, 208, 209. 1949. JANUARY—W-211, 212, 213, 214, 215, 216.

NEW POSITIONS OPEN

SALES ENGINEER for overhead sprinkler systems, to contact growers and establish dealers in one or more of the states of Michigan, Illinois, Wisconsin, Minnesota, and Iowa. Agricultural or mechanical engineering background. Experience in selling pumping or overhead irrigation euipment or training for work in this field desirable. Location preferably in or near Chicago, but arrangement for residence in any of the states indicated may be possible. Opportunity depending on ambition and willingness to work. Age 25-30, or older man with irrigation experience. Salary $2700-10,000, depending on ability to sell. O-656

OFFICE ENGINEER for design of irrigation systems, preparation of quotations, and related engineering for irrigation equipment engineering and sales organization. Agricultural or mechanical engineering background. Some general office experience desirable but not required. Location in or near Chicago or Aurora, Ill. Opportunity to work toward sales engineering or office and plant management. Age 25-30. Salary $2700 - 3500. O-657.

DESIGN ENGINEERS (2 or more) for work on combine harvesters and on other harvesters and implements. BS deg in agricultural engineering or equivalent. Any design or related engineering experience in the farm equipment field would be helpful. Usual personal qualifications for commercial design. Location Ontario, Canada. Opportunity up to individual. Salary open. O-658

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires teaching and research in power and machinery in public service, or design, development, and research in private industry. BS deg in agricultural engineering, 1948, University of Tennessee. MS deg in agricultural engineering expected in March 1949, Michigan State College. General work in small dairy, 5 yr. Graduate assistant, Michigan State College, 1 yr. Enlisted and commissioned service in U S Naval Reserve, 35 mo, including 12 mo sea duty. No disability. Available April 1. Married. Age 24. Salary open. W-217.

AGRICULTURAL ENGINEER desires development, sales, service, extension or project engineering work in farm structures, power and machinery, or soil and water field. BS deg in agriculture with major in agricultural engineering, 1948, McGill University. Dairy farm background, with additional work on fruit, grain, and tobacco farms. Several months as repairman for DeLaval Co, Ltd. Special salesman on barn and stable equipment for the Pedlar People, Ltd., 8 mo. War service with RCAF, 3 yr. No disability. Available on 30 days notice. Married. Age 25. Salary open. W-218

AGRICULTURAL ENGINEER desires design, research, or sales work in farm structures or soil and water field with private company. BS deg in agricultural engineering expected in March, University of Tennessee. Farm background and experience with all types of farm machinery. Machine shop experience 2 yr. War service 29 mos, with Corps of Engineers. No disability. Available March 17. Married. Age 26. Salary $3000-3600. W-219.

AGRICULTURAL ENGINEER desires sales and service work in industry, or project engineering in government agency, in power and machinery or rural electric field. BS deg in agricultural engineering expected in June, requirements to be completed March 19, North Carolina State College. Farm background; electrical repair work, 4 mo; motion picture projectionist 12 mo; farm equipment company service and shipping department, 3 mo. War service in Field Artillery and Army Air Force 4½ yr, mostly as motion picture projectionist and repair man. No disability. Available April 1. Married. Age 29. Salary open. W-220.

AGRICULTURAL ENGINEER desires extension, research, or teaching in soil and water or power and machinery field, preferably with land-grant college or federal agency. BS deg in agricultural engineering, Kansas State College, 1934. MS deg in agricultural engineering, University of Georgia, 1942. Progressive experience with SCS, 10 yr. Extension agricultural engineer 3½ yr. No disability. Available on 60 days notice. Married. Age 38. Salary open. W-221

AGRICULTURAL ENGINEER desires design and development or teaching in either power and machinery or soil and water field, in pub-

(Continued on page 104)

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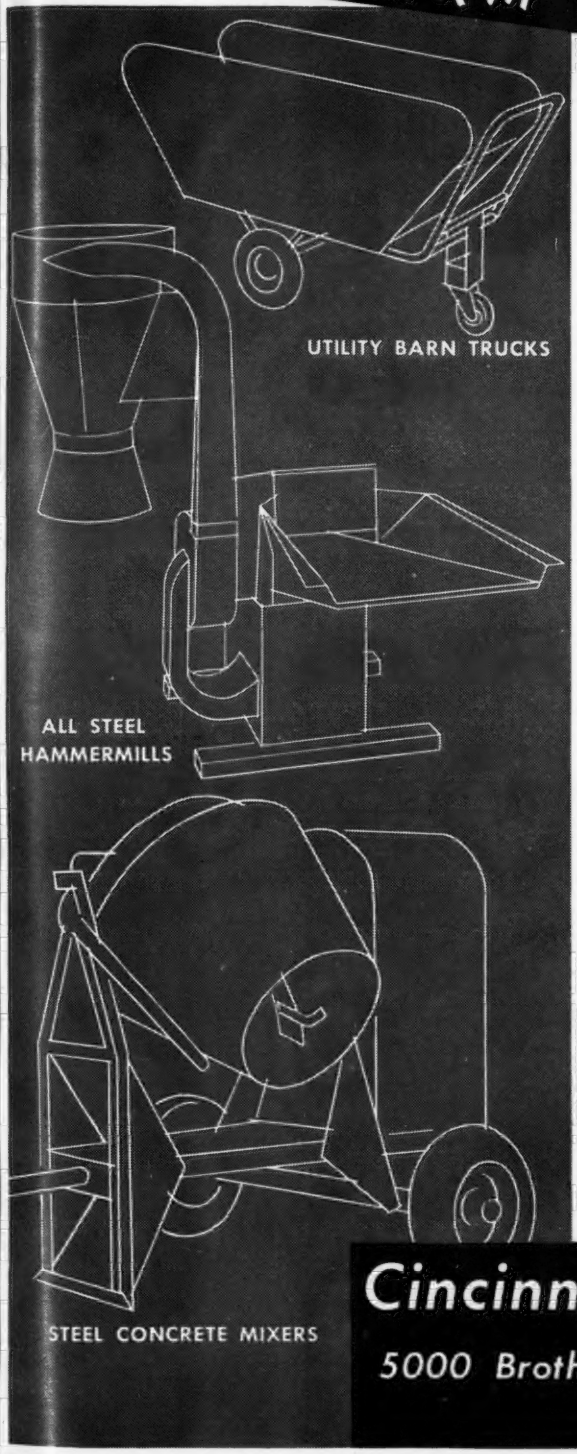

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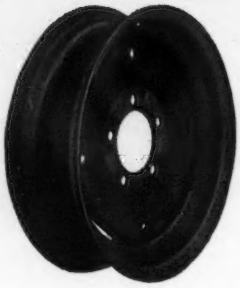

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 102)

lic service or private employment. BS deg, 1947, and MS deg expected June 1949, in agricultural engineering, University of Missouri. Clerical supervisor in government office 5 yr. Research assistant in agricultural engineering, one semester. War service 3 yr in Army Air Force as mechanic on synthetic training devices. No disability. Available September 1. Married. Age 32. Salary open. W-222

AGRICULTURAL ENGINEER desires research, design, development, production, sales, or service work in power and machinery field in industry or public service. BS deg in agricultural engineering expected in March, University of Tennessee. Experience as a cooperative student, with Aluminum Co of America, in pyrometric work on heat treating, annealing remelter furnaces, and rolling mill. War service 3 yr in Army Air Force with promotion to 1st Lieutenant, and rating as pilot and instructor, four-engine aircraft. No disability. Available March 28. Married. Age 25. Salary open. W-223

AGRICULTURAL ENGINEER desires irrigation or other engineering work in soil and water field, in development or service. BS deg in agricultural engineering expected in May, University of British Columbia. Field and office experience with water rights and public works branches of the provincial government. Enlisted and commissioned service 4 yr, Canadian Armored Corps. No disability. Available in May. Married. Age 27. Salary open. W-224

AGRICULTURAL ENGINEER desires service, development, or sales work in soil and water or farm power and machinery field, with industry or project or entension work in public service. BS deg in agricultural engineering expected in March, University of Minnesota. Assisted in farming and managing 360-acre grain and livestock farm, 4 yr. War service 3 yr as aircraft mechanic, Army Air Force. No disability. Available March 28. Married. Age 27. Salary open. W-225

AGRICULTURAL ENGINEER desires design, development, research, sales or service work in power and machinery or farm product processing field, with private industry. Will go anywhere in the United States but location in South preferred. BS degree in agricultural engineering expected in March, University of Tennessee. War service in Navy 4½ yr; rating machinist mate. No disability. Available April 1. Married. Salary open. W-226

New Literature

METHODS OF APPLYING FERTILIZER (revised November 1948) paper, 28 pages, 6x9 inches. National Joint Committee on Fertilizer Application, 616 Investment Bldg., Washington, D.C.

This brings up to date a bulletin of the same subject originally published by the Committee in 1938. It covers briefly principles involved in fertilizer use, and recommendations and supplementary information on field crops, vegetable crops, fruits and nuts, application of liquid fertilizers, and fertilizer application equipment. Brief information on the organization of the Committee is included.

THE PAY-OFF IN RESEARCH. Paper, 48 pages, 6x9 inches. Illustrated. 50 cents. Engineering College Research Council, American Society for Engineering Education. (University of Iowa, Iowa City.)

A narrative report of specific examples of fundamental research in engineering colleges which have proven of significant practical value to the nation. They are presented in brief chapters on dehumidifier testing laboratory, low cost housing, parking meters, transit system modernization, tractor testing, science of sferics, analysis of gases in steel, nepheline syenite, sugar beet mechanization, flax-handling machinery, school architecture, and spectro-chemical analysis. This report is based on the research activities of 73 institutional members of the ASAE.